The Afghanistan Engineering Support Program assembled this deliverable. It is an approved, official USAID document. Budget information contained herein is for illustrative purposes. All policy, personal, financial, and procurement sensitive information has been removed. Additional information on the report can be obtained from Firouz Rooyani, Tetra Tech Sr. VP International Operations, (703) 387-2151.

ENGINEERING SUPPORT PROGRAM

Contract No. EDH-I-00-08-00027-00
Task Order No. 1
Work Order WO-LT-0070 AMD5

Tarakhil Power Plant Alternative Fuels Evaluation

February 26, 2015

This publication was produced for review by the United States Agency for International Development.
It was prepared by Tetra Tech, Inc.

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February 26, 2015

Jeffrey Kaufman, COR
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Re: Contract No. EDH-I-00-08-00027-00 / Task Order No. 1
Afghanistan Engineering Support Program (AESP)
Work Order WO-LT-0070 AMD 5
Tarakhil Power Plant Alternative Fuels Evaluation

Dear Mr. Kaufman and Ms. Katin,

Tetra Tech AESP is pleased to submit this report for the evaluation of alternative fuels at the Tarakhil Power Plant in Kabul, Afghanistan. The report reviews and provides a financial analysis for three alternative fuel sources; Diesel Oil (DO), Heavy Fuel Oil (HFO), and Compressed Natural Gas (CNG).

The Tarakhil Power Plant (TPP) currently operates at only a small fraction of its production capability due in part to the availability of low-cost import power. Thus the TPP is primarily operated to support peak loading during the winter months rather than continuous base load operations. Each fuel type is evaluated twice; first assuming an operational life of 7 years, then assuming an operational life of 21 years for the power plant in base load operations.

HFO is the preferred alternative fuel in the near term and CNG is the preferred alternative fuel in the long term for base load operations. However, the operational readiness of the TPP to accept or operate HFO is unknown, and 2 to 3 years is anticipated before the TPP could accept HFO for base load operations. Consistent with the findings and recommendations of previous studies reviewed herein, this evaluation concludes that DO is the preferred fuel for near term operation of the TPP until the HFO system commissioning and operator training are complete.

Construction of a pipeline to transport CNG from the Sheberghan gas fields should be evaluated further. A properly sized pipeline could provide a reliable, low cost fuel source to the TPP. This pipeline would have the added benefit of providing a significant supply of CNG to the Kabul area.

Respectfully,
Tetra Tech, Inc.

Michael J. Petti, PE, BCEE
Chief of Party (AESP)

cc: Abdul Rasool Wardak (USAID OEGI)
Kevin Pieters (USAID OEGI)

AFGHANISTAN ENGINEERING SUPPORT PROGRAM

Contract No. EDH-I-00-08-00027-00
Task Order No. 1
Work Order WO-LT-0070 AMD 5

Tarakhil Power Plant Alternative Fuels Evaluation

February 26, 2015

EXECUTIVE SUMMARY

The Tarakhil Power Plant (TPP) currently operates at only a small fraction of its production capability due in part to the availability of low-cost import power. The TPP is primarily operated to support peak loading during the winter months.

This report provides an overview of previous alternate fuel evaluations and summarizes financial analyses to identify a preferred fuel for TPP. Diesel oil, heavy fuel oil, and compressed natural gas are considered within the scope of this report. Each fuel type is evaluated twice, first assuming an operational life of 7 years, then assuming an operational life of 21 years for the power plant.

Although the compressed natural gas option presents the lowest overall fuel cost for generation at the TPP, the pipeline infrastructure necessary to reliably transport fuel to the facility is not presently in place. A large capital investment will be required to facilitate efficient transport of compressed natural gas to TPP. This investment makes natural gas an unattractive option.

Consistent with the findings and recommendations of previous work orders WO-LT-0036 and ICT-004-10, diesel oil is the preferred fuel for near term (~5 year) operation of the TPP. The viability of alternative fuels improves substantially as the operations planning window is extended past 20 years, with compressed natural gas providing the lowest levelized cost of energy (LCOE) of the evaluated alternatives for that timeframe.

Due to system complexities and limited availability of specialized staff to support heavy fuel oil operations, the TPP should continue to operate on diesel oil until completion of heavy fuel oil system commissioning and operator training.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDICES

1.0 BACKGROUND

The maximum capacity of the Tarakhil Power Plant (TPP) is 105 megawatts (MW). The power plant is designed with three independent power blocks, each with a nominal output of approximately 35 MW. Each power block is equipped with six Caterpillar CM series model 16CM32C diesel engine generator sets with turbochargers. The electric power is generated at 11,000 volts (11 kV) and passes through step-up transformers that feed it to the public grid at 110,000 volts (110 kV).

The engines and support systems are designed for base load operations. Due to economic pressures, the plant is being operated as a peaking plant; providing peak kW support during times when: the Afghanistan hydroelectric resources are low, line maintenance is underway, or when the North-Eastern Power System (NEPS) electrical transmission import connection is at or near capacity. The TPP currently operates at only a fraction of its production capability.

2.0 OBJECTIVE

The objective of this analysis is to review prior work, review and document current operational considerations, and perform financial analysis to evaluate alternative fuel supplies for the TPP.

This analysis evaluates alternatives to diesel oil (DO) fuel that may allow the TPP to operate more economically and on a regular and sustainable basis. This analysis will include the following:

1. Evaluate alternate fuel types and quantify the associated cost of generated electricity on a $/kWh basis.
2. Perform a financial analysis to determine the Net Present Value (NPV), Internal Rate of Return (IRR), Benefit-Cost Ratio (BCR) and payback period for an investment pertaining to each alternative fuel option. Estimate the capital expenditure (CAPEX) required for each investment option.
3. Screen fuel alternatives and recommend a preferred fuel feedstock for the TPP based on the Levelized Cost of Energy (LCOE) and the financial feasibility analysis.

3.0 EXISTING HFO ASSESSMENT REPORTS AND DATA

3.1.1 ICT-004-10

ICT-004-10 was commissioned during TPP construction and is in response to a report by the Special Inspector General, Afghanistan Reconstruction (SIGAR) dated January 20, 2010. The report describes delays and cost overruns that arose during the construction of the TPP. The report is attached as Appendix A.

SIGAR recommended as follows:

To help ensure the long term sustainability of the Kabul Power Plant, SIGAR recommends that the USAID Mission Director in Afghanistan produces a definitive study on the technical feasibility and advisability of using heavy fuel in the Kabul Power Plant and factor this information into plant completion decisions and any decisions regarding post-construction use of heavy fuel oil by the GIRoA.

POWER Engineers assessed the technical feasibility and advisability of using Heavy Fuel Oil (HFO) at TPP, finding that the plant was designed and technically capable of operating on HFO. Similar plants operating in other locations have a successful operating history with HFO.

The assessment concluded that a fuel cost savings of approximately $27M/yr could be realized by operating the TPP on HFO as opposed to diesel if the following conditions are met:

1. Adequate supplies of heavy and light fuel oils can be secured

2. The TPP is operated at full load
3. Skilled operators are available to operate the HFO facilities

The assessment concluded that using HFO would impose a larger burden on operations and maintenance compared to similar operations on DO, and there will inevitably be a penalty in terms of plant availability. Staff training would be more arduous, and personnel experienced in running this type or similar types of plant were not readily available in Afghanistan.

The final recommendation was to operate the plant near term (1-3 years) on DO, transitioning to HFO in the medium to long term (3-5 years) to take advantage of the significant fuel cost savings available as skilled operations staff becomes available.

3.1.2 WO-LT-0036

The WO-LT-0036 Rev.0 report was issued June 14, 2011. This report documents the findings of an on-site operational evaluation conducted at the request of USAID to determine the operational, technical, and physical constraints preventing the plant from operating at its full designed capacity.

Evaluation teams were deployed for approximately four weeks to the project site to review the design specifications, storage of engines, other construction activities, commissioning activities, and current plant operations. At the time of the WO-LT-0036 evaluation effort, TPP was operated exclusively on a DO supply source. Issues and concerns with transitioning the plant to operate on HFO were considered. The evaluation team determined that engines and support systems were in place to operate the generating facility on diesel or HFO feed stocks once received at TPP, but had not been commissioned.

The TPP was designed as a base load plant, operating 24 hours/day, 7 days/week, but was being operated to support peak loading only. The plant was being operated at approximately 4% of its MWh capacity.

DABS had contracted for immediate delivery of HFO to TPP to be received at a rate of six truckloads per day from Karachi, Pakistan. Transit time from the refinery to the offload site was estimated at 8-10 days. Because the available trucks were neither heated nor insulated, reheating would have been required to attain the 50°C design temperature at the offloading facility. Heating time was estimated at 11 hours per truck. The report concluded that physical infrastructure was in place to accommodate receipt and unloading of up to six HFO tankers per day.

The delivered cost of HFO was approximately 25% less than DO at the time of the evaluation. The WO-LT-0036 operational evaluation determined that there was a cost savings to operate on HFO either when using the plant as a peaking plant or when using the plant for base load operations. Factoring in the additional heating and maintenance costs for HFO, the evaluation concluded that the net cost per MWh is reduced (versus diesel) when operating each engine in excess of 2,500 hours per year.

WO-LT-0036 identified the critical issues to be addressed before receiving HFO at TPP. These issues included:

- Insulation of HFO equipment
- HFO system commissioning
- Specialized HFO system operator training
- Development of operating procedures

Follow-up and re-evaluation of the TPP readiness for HFO operations is beyond the scope of the current task order. The analysis in this report assumes that the TPP HFO physical configuration and operational status remain as found during the WO-LT-0036 on-site evaluation effort.

3.1.3 Phoenix Assessment of HFO at TPP

In the summer of 2014, Phoenix IT Solutions Ltd (Phoenix) was contracted by USAID to assist DABS in the operation of the TPP. Phoenix performed an assessment of the cost-effectiveness of operating TPP on HFO. A summary of this analysis was transmitted to USAID on October 3, 2014 and is included as Appendix B for reference. The analysis considered current operational practices for the facility and concluded that potential savings to be obtained by operating the TPP on HFO in lieu of DO would be 21% at full load and 11% when operated 6 hrs/day.

The Phoenix analysis considers costs associated with part-time operation of the facility not considered in previous analyses such as:

- Engines must be flushed with DO after each operating cycle with HFO
- Two auxiliary boilers and six circulating pumps will be operated 18 hrs/day, providing heat to the HFO system when generators are not operating

3.1.4 Current Plant Conditions Summary

- TPP is currently operated on diesel fuel, supplied by trucks
- HFO may be readily sourced from neighboring countries (Pakistan)
- Because DO is currently stored in HFO storage tanks at TPP, minor plant operational modifications will be required to unload DO at TPP
- Physical infrastructure is in place to operate TPP on either DO or HFO
- Commissioning of the HFO system will be required prior to any operations
- New operating procedures and operator training will be required for the HFO system
- O&M costs for HFO operation will be higher than those for DO
    - Auxiliary process heating is required when the plant is offline
    - Dedicated operations staff, in addition to those required for DO operations, will be required for HFO operations at TPP

4.0 NATURAL GAS ALTERNATE FUEL SUPPLY

4.1 DUAL FUEL TECHNOLOGY OVERVIEW

The TPP diesels may be modified to accept compressed natural gas (CNG) as a primary fuel feedstock. A typical fuel gas blending arrangement would involve installation of aftermarket CNG piping and controls to the existing engines. Packaged dual fuel (DF) systems are presently manufactured and marketed by original equipment manufacturer (OEM) and aftermarket suppliers.

The WO-LT-0070 AMD 5 SOW prescribes a CNG fuel fraction of 90% when operated in DF mode. Standard industry practice indicates that the actual DO fuel replacement will be in the range of 70%[1]. The following discussion assumes a fuel of 0.7 (CNG/Total Fuel) based on heating value.

In DF operations, DO must be maintained as a fraction of the fuel feed. This fuel fraction provides an ignition source for the DO/CNG fuel mixture. Each gallon of diesel fuel displaced during DF operation is replaced by approximately 140 standard cubic feet (SCF) of pipeline-quality natural gas (based on 129,000 BTU/gallon # 2 diesel & 930 BTU/SCF natural gas).

Operational efficiencies and reliability are similar under DF and traditional DO feeds. Modifications for dual fuel operations do not preclude the system from operating on 100% DO. Dual fuel systems are readily switchable between DO and DF operating modes.

DF operating expenses were analyzed and are presented in the “Financial Analysis” section.

[1] For example, Cummins states: “A maximum substitution rate of 70 percent can be achieved with Cummins Dual Fuel for applications with high load factors.” http://cumminsengines.com/dual-fuel

4.2 CNG FUEL SUPPLY

4.2.1 CNG Delivery by Truck – "Virtual Pipeline"

Assuming CNG is trucked to TPP, current technology limits shipment size to approximately 9,910,000 L/truck (350,000 SCF/truck). Approximately 1.2 CNG tankers per hour (28 CNG tankers /day) would be required at TPP to support full load operation[2].

The tankers would be specialized for transport of liquefied natural gas (LNG) from a compressing station. Re-gasification and CNG holding facilities would be required at TPP.

Due to the large logistics issues associated with coordination, shipping, and unloading of up to 28 LNG tanker trucks per day to TPP, delivery by truck is not believed to be a viable option. Truck delivery of LNG to TPP will not be discussed further in this report.

4.2.2 Pipeline Construction (Sheberghan to TPP)

4.2.2.1 Fuel Pricing

CNG pricing as received at TPP is assumed to be competitive with international pricing in the region and based on Pakistan OGDC market pricing ($2.79/MBTU) for the purpose of this evaluation.

4.2.2.2 Pipe Sizing

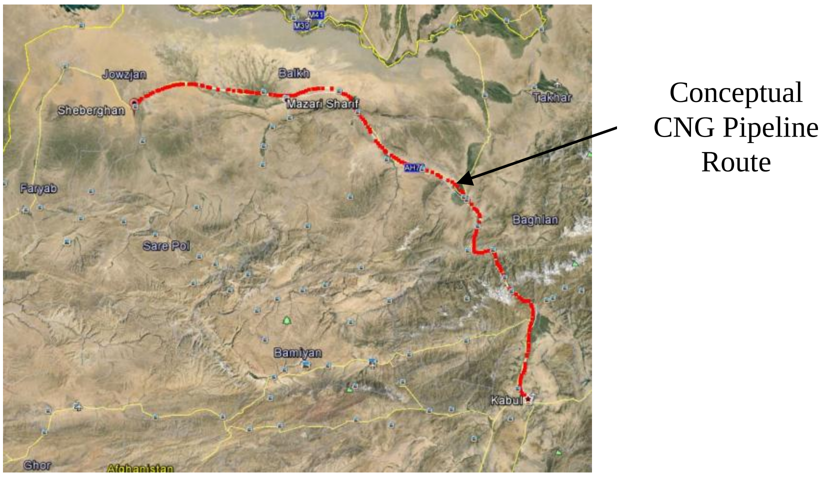
To provide a CNG capacity of approximately 5x the TPP demand at full load, a 203.2mm (8in) inside diameter pipe is proposed for installation from Sheberghan to TPP.

It is assumed that the new pipeline will follow existing highways, sharing the existing right-of-way. The approximate length of this route will be 509km. The conceptual gas line route is presented as Figure 1.

This analysis assumes that sufficient sweet gas supplies are available at Sheberghan to support TPP and additional loads in the Kabul area. Pipeline sizing summary calculations are included in Appendix C.

[2] 15,500,000L/day CNG per unit * 18 units = 279,000,000L CNG/day; 279,000,000L/d / 9,910,000L/truck= ~28 trucks/day.

Figure 1. Sheberghan to TPP Conceptual CNG Pipeline Routing



4.2.2.3 Pricing Basis

The Turkmenistan–Afghanistan–Pakistan–India (TAPI) pipeline is a proposed CNG pipeline being developed by the Asian Development Bank. While larger than the conceptual Sheberghan-to-TPP pipeline described above, the TAPI pipeline provides a current basis for parametric estimation of construction costs for other projects in the region.

The TAPI pipeline has been designed with the following attributes:

- Diameter - 1,420mm (56in)
- Operating pressure - 101.325bar (100 ATM)
- Length – 1,735km
- Compressors - 6 (289km/segment)
- Cost – $7.6 Billion

Pipeline construction costs are often estimated on the basis of pipe inside diameter per unit length. Using this approach and the data above, the cost of the TAPI pipeline can be approximated as:

$$3{,}085\frac{\$}{mm \cdot km} \sim 126{,}071\frac{\$}{in \cdot mile}$$

Applying this metric and the characteristics of the Sheberghan to TPP pipeline outlined in section 4.2.2.2, the approximate construction cost for the pipeline will be:

$$3{,}085\frac{\$}{mm \cdot km} \times 203.2mm \times 509km = \$319M$$

An allowance of $21M is assumed to support upgrades at the TPP to support CNG mixed fuel operations. The total capital investment to be applied to the CNG option is $340M, including modifications at TPP.

5.0 FINANCIAL ANALYSIS

5.1 ANALYSIS RECAP

A *pro forma* financial analysis has been performed to evaluate each alternative fuel option. The following criteria were evaluated for each alternative (DO, HFO, and CNG/DF):

- Levelized Cost of Energy (LCOE)
- Net Present Value (NPV)

- Individual Rate of Return (IRR)
- Benefit / Cost Ratio (BCR)
- Payback Period

Two scenarios have been considered, assuming operating lifetimes for TPP of:

a. 7 Years
b. 21 Years

The analysis assumes that the DO (status quo) and HFO options can be made available immediately and that TPP will operate at base load beginning with year 0. Scenario "a" assumes 7 years of operation while scenario "b" assumes 21. Both scenarios include salvage of the plant at the end of the last year of operation. It is assumed that TPP will support base load operations (100MW) for the duration of the financial analysis period.

The CNG/DF option is estimated to require 3 years to construct and commission. Base load operations are projected to begin at the end of the 3 year construction and commissioning period and continue for a period of 4 years in scenario "a" and 18 years in scenario "b", with both scenarios including salvage of the plant at the end of the last year of operation. TPP is assumed to support peak load operation during CNG construction, operating 30 days/year at 30% capacity (30MW). Upon completion of construction and commissioning, the plant is assumed to operate at base load (100MW) for the duration of the analysis period. Of note, the plant is currently operating at less than 3% capacity, so this assumption does not reflect current plant conditions.

All scenarios have been evaluated to determine the electricity tariff (LCOE) at which the NPV=$0. The break-even tariff is the specific tariff that must be charged for any alternative to reach NPV=$0 within the operational life of the facility. Increasing the levied electricity tariff above the break-even point increases the NPV of the alternative. A tariff below the break-even point results in a negative NPV and indicates that the TPP would operate at a net loss under the evaluated financial conditions. A discount rate of 9.5% was used to compute NPV.

To evaluate each case, the LCOE for the status quo was computed, and that value was used as an assumed tariff rate. This models a situation where rates remain the same, but investments are made in the plant which change the actual cost of generation. Table 1 provides a summary of the analysis criteria evaluated for the three options considered (DO, HFO, CNG/DF) and two lifecycle scenarios (7 years, 20 years). *Pro-forma* financial model worksheets for each alternative have been included in Appendix D.

Table 1 Financial Analysis Summary

Lifecycle Scenario	**a. 7 YEARS**			**b. 21 YEARS**		
Fueling Alternative	**DO**	**HFO**	**CNG/DF**	**DO**	**HFO**	**CNG/DF**
LCOE ($/kWh)	0.269	0.215	0.322	0.276	0.221	0.195
Assumed tariff ($/kWh)	.269	.269	.269	.276	.276	.276
NPV ($M)	0	186	-82,190	0	311,747	333,039
IRR (%)	N/A	N/A	2.19	N/A	N/A	19.74
BCR	N/A	16.75	0.1	N/A	44.66	1.516
Payback Period (years)	N/A	.55	>project life	N/A	.55	9.5

5.2 ALTERNATIVES RANKING

Based on financial criteria alone, HFO is the preferred alternative fuel for scenario "a" (7 Year operation) and CNG is the preferred alternative for scenario "b" (21 year operation). As the financial criteria are based on generating power and selling it at a tariff rate above the cost of generation, finances are highly dependent on the amount of power generated. If the plant is operated at less than base load (100 MW), selling fewer profitable kW-h's, the financial performance will suffer materially.

Additionally, several factors including operational readiness, operator availability, fuel availability, and overall reliability should also be considered when selecting the preferred fuel alternative. Table 2 presents a summary of criteria and relative rankings to identify the preferred alternative. In this ranking process, the most preferred alternative for each scenario is ranked "3" and the least preferred alternative is ranked "1". When scores for all criteria are summed, the preferred alternative for each scenario has highest score.

Table 2 Alternatives Ranking

Lifecycle Scenario	**(a)7 YEARS**			**(b)20 YEARS**		
Fueling Alternative	**DO**	**HFO**	**CNG/DF**	**DO**	**HFO**	**CNG/DF**
Financial						
Financial Analysis	2	3	1	1	2	3
Operations						
Equipment Readiness	3	2	1	3	2	1
Staff Training / Quals	3	2	1	3	2	1
Procedures	3	2	1	3	2	1
Maintenance	3	2	1	3	2	1
Operations Complexity	3	1	2	3	1	2
Fuel Cost	1	2	3	1	2	3
Construction						
Capital Construction	3	2	1	3	2	1
Commissioning	3	2	1	3	2	1
Totals						
Total	**24**	**18**	**12**	**23**	**17**	**14**

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

6.1.1 7-Year Operation Lifecycle

The CNG option presents the lowest overall fuel cost for generation at TPP, but the infrastructure to reliably transport "sweet" CNG from the Sheberghan gas fields or other international sources to TPP is not in place. It is unlikely sufficient supplies of CNG can be made available in the vicinity of TPP to support base load operations before additional import power becomes available and TPP is decommissioned and scrapped (estimated to be within 5 years). Due to the large capital investment required and short operational life, CNG is not a desirable alternative fuel for TPP in the near term.

The financial analysis assumes a best case scenario where the HFO option is immediately available. While physical infrastructure and equipment are in place to operate TPP on HFO, the commissioning status and operational readiness of HFO handling systems and equipment are unknown. Full commissioning of the HFO system, including specialized operator training and qualification, will be required. HFO system commissioning and operator training and qualification are anticipated to require a period of 2-3 years to achieve full operational readiness.

Financial analysis also assumes that plant will operate at base load (100MW), generating 633,600 MW-h per year of power. As of 02 Mar 2014, the plant (averaging 2.3% capacity) had generated 91,809 MW-h in its lifetime. Because the positive-NPV projections rely on selling power at a profit, if the plant is not operated at base load, less power will be generated, and less income will be realized.

Consistent with the findings and recommendations of WO-LT-0036 and ICT-004-10, DO is the preferred fuel for near term operation of TPP.

6.1.2 21-Year Operation Lifecycle

If the planning window is extended to 21 years, the viability of alternative fuels improves substantially. The LCOE for CNG drops from $0.322/kWh to $0.195/kWh. While this cost is still above the current $0.18/kWh tariff, it assumes the entire cost of the Sheberghan – TPP CNG pipeline is recovered through CNG operations. In reality, this cost would be significantly offset by the sale of excess CNG (~406,000,000 SCM/Year) in the Kabul area as the source becomes available and load is developed.

6.2 RECOMMENDATIONS

The operational readiness of the TPP to accept or operate on HFO in the near term is unknown. TPP should continue to operate on DO until such time as HFO system commissioning and operator training are complete.

DO will be required to support startup and shutdown of the facility, but TPP should transition to HFO for base load operations as soon as operational readiness is achieved.

Construction of a pipeline to transport CNG from the Sheberghan gas fields or an alternate international source should be evaluated further. A properly sized pipeline could provide a reliable, low cost fuel source to TPP. This pipeline would have the added benefit of providing a significant supply of CNG to the Kabul area to support new and existing thermal loads.

APPENDICES

APPENDIX A
KABUL 100 MW POWER PLANT HFO AUDIT (ICT-004-10)

Tetra Tech

Kabul 100MW Power Plant

HFO Audit

PROJECT NUMBER:
1454

DOCUMENT NUMBER:
ICT-004-10

[redacted]

POWER ENGINEERS

1	Issued to client	SD	25 Mar 2010	MA	25 Mar 2010
0	Issued to client	SD	25 Feb 2010	MR	25 Feb 2010
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A	Issue of preliminary, incomplete draft	SD	23 Feb 2010		
Rev.	**Details**	**Author**	**Date**	**Checked by**	**Date**

EXECUTIVE SUMMARY

The Special Inspector General – Afghanistan Reconstruction (SIGAR) in its report dated January 20, 2010, reported on the delays and cost overruns that have arisen during the construction of the 100MW diesel/heavy fuel oil power plant at Tarakhil, Kabul.

SIGAR recommended as follows:

To help ensure the long term sustainability of the Kabul Power Plant, SIGAR recommends that the USAID Mission Director in Afghanistan produces a definitive study on the technical feasibility and advisability of using heavy fuel in the Kabul Power Plant and factor this information into plant completion decisions and any decisions regarding post-construction use of heavy fuel oil by the GIRoA.

POWER Engineers was asked by Tetra Tech to assess the technical feasibility and advisability of using heavy fuel oil in the Kabul Power Plant.

This report finds that the plant is technically capable of operating on heavy fuel oil: the plant used is designed for this fuel and there is a long history of similar plant operating successfully. Provided that a supply of fuel can be secured, and assuming that the plant can be run at full load, fuel cost savings of some $27 million per year can be expected when compared to the same operating duty using diesel oil.

Preliminary indications are that adequate supplies of heavy and light fuel oils can be secured.

However, using heavy fuel oil will impose a larger burden on operations and maintenance compared to similar operation on diesel oil, and there will inevitably be a penalty in terms of plant availability. Staff training will be more arduous – and personnel experienced in running this type or similar types of plant are of course not readily available in Afghanistan.

Furthermore we understand that there is insufficient load on the local electricity system to enable the plant to reach full load and this is likely to continue for several years. If the maximum plant load is only 20% of its capacity then the fuel savings will be correspondingly lower.

Recommendations

We recommend that the plant is operated on heavy fuel oil in the medium to long term in order to take advantage of the significant fuel cost savings available. However, in view of the current lack of load and the shortage of skilled staff, we recommend that in the short term the plant is completed, commissioned and operated firstly on diesel fuel. We recommend that this is facilitated by a two-phase completion and commissioning program as follows.

The first phase would be to bring the plant into full operation on diesel fuel, and equipment not required for diesel fuel operation should be sealed and preserved until the second phase of commissioning. The exception to this is the heavy fuel storage tank shells, the construction of which should be completed now.

Staff training can be focused on diesel fuel operation only, which will more quickly bring about the situation where locally employed staff can take on responsible roles in operating the station.

We then recommend that a second phase of commissioning be performed when the available load and the staff capabilities permit the plant's heavy fuel oil capability to be brought into operation.

TABLE OF CONTENTS

1. Introduction

The power station under construction at Tarakhil, Kabul, Afghanistan, comprises 18 medium-speed heavy fuel diesel engines, model 16CM32C, supplied by Caterpillar from their facility in Germany which was formerly MaK. These engines are typical for the application, and though as many as 18 units in one power plant is not common, it is not unreasonable.

The Special Inspector General – Afghanistan Reconstruction (SIGAR) in its report dated January 20, 2010, reported on the delays and cost overruns that have arisen during the construction of the 100MW diesel/heavy fuel oil power plant at Tarakhil, Kabul.

SIGAR recommended as follows:

To help ensure the long term sustainability of the Kabul Power Plant, SIGAR recommends that the USAID Mission Director in Afghanistan produces a definitive study on the technical feasibility and advisability of using heavy fuel in the Kabul Power Plant and factor this information into plant completion decisions and any decisions regarding post-construction use of heavy fuel oil by the GIRoA.

As a result, POWER Engineers was asked by Tetra Tech to assess the technical feasibility and advisability of using heavy fuel oil in the Kabul Power Plant.

POWER Engineers' scope is as follows:

a) Provide an overview describing the reasons for using heavy fuel oil and the extent of its use in plant similar to the Kabul Power Plant.

b) Describe the technical challenges and requirements for operating the plant on heavy fuel oil as opposed to operating on diesel fuel oil.

c) Review the existing design drawings and data, in order to determine what modifications would be required if a change to operate on diesel fuel only were required.

d) Describe the likely differences in staffing levels and training requirements for operating the plant on heavy fuel as opposed to operating on diesel fuel oil.

e) Report on the availability and price of both heavy fuel and diesel fuel oil in Kabul, taking into consideration the likely supply routes and security of supply.

2. Note on Terminology used in this Report.

To avoid ambiguity, the meanings of certain terms are described below. These are all consistent with normal practice in the diesel / heavy fuel engine field.

Diesel engine: any reciprocating piston engine that operates on the compression ignition cycle, whereby the heat generated by compressing air in the engine's cylinders causes liquid fuel, when injected into the hot air in a fine spray, to ignite. No spark plugs or other sources of energy are used. The term "diesel engine" does not imply any particular fuel: the diesel engine was named for its inventor, Dr. Rudolph Diesel, and diesel fuel was developed for it.

Compression ignition engine: this term is completely interchangeable with "diesel engine".

Medium speed: this is not a tightly defined term, but refers to engines operating at speeds of between typically 400 rpm and 1000 rpm, usually using the four-stroke cycle. The engines in question for this report fall into this category. (Other categories are "high-speed", which refers to engines operating at speeds above 1000 rpm, and "low-speed" which operate below 400 rpm and usually use the two-stroke cycle. High-speed engines are generally not suitable for HFO operation; most low-speed engines operate on HFO.)

Heavy fuel oil or HFO: this is the fuel primarily used in medium (and low) speed engines *(q.v.)* in the vast majority of marine and land-based applications.

Distillate fuel / diesel oil / light diesel oil: these terms are interchangeable.

3. Overview of HFO Usage

3.1 What is Heavy Fuel Oil?

When crude oil is refined the lighter fractions are extracted to produce petrol, diesel oil (gas oil), medium grade fuels, lubricating oils, etc., leaving a heavy, viscous, black fluid that typically does not pour at room temperature and is difficult to burn. This “residual oil” is the main constituent of commercial heavy fuel oil (HFO).

For commercial use, residual oil is blended with lighter oils in order to achieve consistent combustion qualities, viscosity, pour point and contaminant levels. It is commonly available today in several grades, broadly differentiated by viscosity at a nominal temperature, generally 50°C.

HFO tends to contain higher levels of ash, sulphur, sodium and vanadium than the more refined fuels, as well as water and sometimes solids such as catalytic fines, dust and even sand, depending on the source and refining process. All of these are undesirable and present challenges to the engine builder.

3.2 Why Use Heavy Fuel Oil?

The 1973 oil crisis prompted the oil-dependent developed countries to look at how their growth in oil consumption could be constrained, leading to improvements in the efficiency of oil consuming equipment and to maximizing the use of the lower-value products of crude oil.

In particular, the manufacturers of reciprocating compression ignition engines, i.e. diesel engines, began to develop their engines to operate on increasingly heavy fuels in order to offer lower cost operation, especially to the marine world’s merchant fleet.

Nowadays the vast majority of merchant ships operate on HFO, as does the vast majority of the larger diesel engines used for power generation on land. The requirement of the marine industry to reduce emissions of sulphur, which is always present to some degree in the HFO it uses, has pushed up the price of HFO but nevertheless HFO purchased in bulk today is typically some 30% less costly than diesel oil.

A 100MW diesel power plant operating at full load will consume some 150,000 tonnes of fuel per year. Using today’s typical market prices[1] for marine fuel available at the major world ports, this quantity of HFO would cost $70 million. To use diesel oil instead would cost $97 million. Fuel at site is likely to be more costly because of the need to transport it considerable distances by road tanker.

So essentially, HFO is used because it is cheaper than diesel oil, and nowadays the problems faced by the users have been overcome to the extent that the availability of a power plant operating on HFO is not far behind a similar plant operating on diesel.

[1] February 22, 2010. Singapore bunker fuel prices: Marine Gas Oil $647/mt; IFO380 (HFO) $468/mt

4. Technical Issues in Using HFO

4.1 Introduction

The use of HFO in diesel engines presents a number of challenges to the designers of engines and ancillary systems. These challenges have been met over the last 30 years or more to the extent that virtually all commercially available medium speed diesel engines today are essentially heavy fuel oil engines. This means that HFO engines are the normal standard design for today's diesel engines, and HFO capability is not provided by additional or non-standard features.

The fuel specifications for diesel and HFO provided by the engine manufacturer for the Kabul plant are typical of fuel specification used worldwide.

4.2 Fuel Viscosity

Light diesel oil has a viscosity of less than 10cSt at 50°C (122°F), whereas commercial HFO for applications such as the Kabul power plant is available in several standard grades with viscosities of up to 700cSt at 50°C.

Fuel is injected into the engine's combustion chambers through extremely fine spray nozzles at high pressures, and in order to achieve this with HFO its viscosity is reduced to some 10 to 20cSt by raising the temperature. The temperature of the fuel at the injection pumps is typically close to 160°C (320°F). In order to achieve and maintain this fuel temperature, not only does the fuel have to pass over heating elements – heated by electricity, steam or thermal oil – but all the storage tanks and all the HFO pipes must be heated and lagged for thermal insulation.

4.3 Fuel Contaminants

The different undesirable contaminants of HFO are dealt with in different ways.

a) Water and Sludge

Water and the heaviest residual elements are removed by passing the fuel through a centrifuge plant. Though the bulk density of HFO at room temperature is often greater than that of water, as the temperature is raised the density of oil falls more quickly than that of water, and when the point is reached that the oil is lighter than water, the water can be removed in a centrifuge. As well as removing water, the heaviest one or two percent of the fuel, comprising waxy and tar-like compounds, will also be removed, thus improving the fuel's injection qualities.

All HFO diesel engine installations include centrifuge equipment to clean the fuel. This results in a cleaner and less contaminated fuel, but also a sludge waste product which must be disposed of. Sometimes the sludge is burned at site with a dedicated sludge burning furnace, and sometimes it is removed from site by a specialist contractor for disposal elsewhere.

b) Catalytic Fines

These are oxides of aluminum and silicon, used to improve the yield of lighter oils in the refining process. Traces can remain in residual oils. The fines are very fine particles but they are very hard and can lead to accelerated wear of fuel injection equipment, pistons, piston rings and cylinder liners, leading to poor fuel combustion and excessive lubricating oil consumption.

Fuel specifications usually limit the quantity of fines permitted, but it is still in the interest of the plant operator to remove as much as possible. The centrifuge plant used to remove water and sludge will also remove a large proportion of catalytic fines together with rust and sand that may also be present.

c) Sodium

HFO generally contains a small amount of sodium, originating from geological salt and sea water contamination. A high level of sodium will give rise to post-combustion deposits in the engine's turbochargers, which can normally be removed by water washing. If sodium is present at high levels, the fuel treatment process sometimes includes mixing small quantities of fresh water to the fuel to dissolve the sodium salts, prior to removal in the centrifuge plant.

d) Vanadium

Vanadium is a metal present in all crude oils in an oil-soluble form. The levels found in residual fuels depend mainly on the crude oil source, with those from Venezuela and Mexico having the highest levels. The actual level is also related to the concentrating effect of the refinery processes used in the production of the residual fuel. There is no economic process for removing vanadium from oil.

Vanadium and sodium in combination can result in high temperature corrosion damage to valve and turbocharger components. As well as minimizing the sodium in the fuel, engine designers have mitigated the corrosion problem with appropriate choices of materials on exhaust valves and exhaust valve seats.

4.4 HFO Handling

The biggest single difficulty in handling HFO is its viscosity. Commercial HFO will have a pour point of typically 30°C (86°F) or more.

This means that delivery tankers must be thermally lagged and fitted with heaters; storage tanks must also be lagged and heated. All piping must be lagged and trace heated, and each engine is arranged so that on-engine piping and the fuel injection equipment can be flushed with diesel oil before the engine is shut down and allowed to cool.

To provide adequate heating for the HFO consumes energy. In the Kabul power plant, most of the heat energy is provided via hot thermal oil, which is heated by the engines' exhaust gases. Thus, the amount of electrical energy used for fuel heating is minimized and the majority of the heat load is met from a source that would otherwise be wasted.

4.5 Operation and Maintenance

Compared with operating on diesel oil only, operations and maintenance staff at the Kabul HFO station need to manage the following.

a) The maintenance of the thermal oil system: exhaust gas boilers, oil pumping and controls.

   Exhaust gas boilers can be demanding to maintain, subject as they are to vibration and, depending on the sulphur content of the fuel, to acidic compounds in the exhaust gas.

b) Fuel treatment plant – modern centrifuge plant is very reliable and as at Kabul it is not uncommon for no redundancy to be included. Two centrifuges, operating in parallel, serve each block of six engines. In the unlikely event of a centrifuge unit being out of service for an extended period, three engines would have to be run on diesel oil or taken out of service. The diesel storage tank has a capacity of 6000m^3 which is sufficient to operate three engines at full load for over 60 days.

c) Fuel pumping and heating modules. These are fairly simple pieces of equipment that normally prove reliable.

d) Lubricating oil – heavy fuel oil combustion will produce more acidic compounds than will diesel oil combustion, mainly because of the higher levels of sulphur in the HFO. Some of these acidic compounds will accumulate in the engine's lubricating oil and when the acidity of the oil reaches a critical level the oil must be replaced. This is normally mitigated by the use of more alkali oils ("high TBN" or total base number oils) which will have a greater capacity to neutralize acids. Depending on the sulphur level in the fuel and the inherent lubricating oil consumption of the engine, it is sometimes possible to choose an oil which never becomes acidic enough to need changing – the amount of alkalinity introduced by topping up the oil to replace that burned, at least matches the acidity added by the combustion of sulphur bearing fuels.

   Nevertheless, it is most likely that the oil usage on HFO will be greater than if HFO were not being used, and the higher TBN oils are often more costly.

   In addition to acidity regulation, HFO combustion in the engine will lead to carbon deposits accumulating in the lubricating oil. These are typically removed by passing the oil through a centrifuge plant. This is very common practice and presents no significant operation issues.

e) Engine components. Under HFO operation the engines will require more frequent attention to fuel injector nozzles, and more frequent cylinder head and piston overhauls. It is difficult to quantify the difference in maintenance requirement because it is highly dependent on the characteristics of the HFO being used, the operating regime and the skills of the maintenance crews. Many HFO power plants use the manufacturer's maintenance schedule as a starting point and tailor their specific maintenance regime in the light of experience on the particular fuel and operating patterns that they experience. However, the life of the aforementioned components when operating on diesel oil is likely to be perhaps double that under HFO operation.

4.6 Plant Availability and Reliability

HFO plant in a well-run environment with structured planned maintenance and well-trained staff would be expected to operate with an overall availability (i.e. taking into account all down-time for any reason, and assuming that the engine would be dispatched 100% of the time if it were available) of 95 to 97%. This may be somewhat lower in the early days while staff become accustomed to the plant, and teething problems are overcome; and of course it will be lower when major overhauls become due after perhaps 7 to 10 years of base load operation.

Operating on diesel oil will be likely to increase overall reliability, and hence availability. Though there is little room for improvement on a well-run plant, a diesel-only operation could attain 98% or even more, as the down-time during overhauls will be shorter.

HFO plant runs most reliably when operated close to full load. Running at reduced loads will lead to carbon build-up on engine valves and turbochargers, which will reduce the engine's efficiency, require more maintenance and reduce component life. Similarly, frequent starting and stopping is not healthy for diesel engines and will reduce component life.

4.7 Converting to Operate on Diesel Fuel Only

All HFO plant use diesel fuel when starting up from cold and when shutting down, in order to flush HFO from the fuel injection system prior to the engine cooling down. Thus there are already two fuel systems in place, so fundamentally there is no need to make any changes to the power station to allow it to operate on diesel fuel only – the operators would simply need to avoid selecting HFO operation on the plant control system.

5. Review of Existing Design with Respect to a Change to Single Fuel

5.1 Overview

In its simplest form, no changes are required to operate the plant on diesel oil only, because it is already arranged to operate on diesel oil or HFO. Simply by not choosing to change the fuel over to HFO on the engines' control panels, operation on diesel oil would continue and the same maximum load can be reached.

Operations and maintenance would then be less burdensome and equipment lives would be extended, as described in the previous section.

If the engines are to be operated on diesel oil for an extended time, it is assumed that it is not the intention to take more than the minimum actions required to provide for long-term diesel oil operation without jeopardizing the facility to operate on HFO in future if required.

5.2 Thermal Oil System

5.2.1 Thermal Oil System Status

The thermal oil system comprises exhaust gas boilers, plus the tanks, pumps, valves and piping to circulate the heated thermal oil through the range of heaters and piping trace heating associated with the HFO system.

Thermal oil exhaust gas boilers have been installed on four out of every six engines (as required for adequate redundancy). The temperature of the engine exhaust gases into the boilers is, according to the Caterpillar manual, 290°C. The boilers will be able to operate dry, i.e. without being filled with thermal oil, without coming to any harm at this moderate temperature.

We understand that the thermal oil piping systems, including trace heating lines, have largely but not completely been installed, and thermal insulation has not been installed yet.

5.2.2 Mothballing the Thermal Oil System

If construction of the thermal oil system is ceased, it only remains to seal open ends of pipes and ensure that the system is preserved for possible future use. Desiccant crystals are available in porous pouches and these should be inserted into pipes and vessels in sufficient numbers to prevent moisture forming and causing corrosion. All open pipes should then be sealed with suitable plugs. It should be possible to readily remove the sealing plugs in order to inspect the interior surfaces and replace when necessary the desiccant crystals.

5.3 Heavy Fuel System

5.3.1 Heavy Fuel System Status

We understand that the HFO piping is largely complete with the exception of thermal insulation, which has not yet been started. Fuel heaters and centrifuge plant have been installed but piping has not yet been completed. The centrifuge plant has not yet been prepared for commissioning – the bowls have not been installed but have been removed from their packaging.

5.3.2 Mothballing the Heavy Fuel Piping

As with the thermal oil plant, desiccant should be inserted into the piping and open ends sealed. Pipework connected to the centrifuge plant should be disconnected from it.

All of the fuel treatment equipment appears to be installed in a dry enclosed building. We would expect this building to be suitable for long-term storage of the equipment provided that open pipes are sealed. Desiccant may be required and though we would advise contacting the manufacturer for recommendations on long-term storage, this is not likely to be difficult.

Photo 1, fuel centrifuges in fuel treatment building

5.4 Fuel Storage

5.4.1 Available Storage

The fuel storage and tanker unloading facilities are not yet complete, but the site is designed to have fuel storage as follows:

1 x diesel fuel storage tank, 6000m^3
2 x HFO storage tanks, each 6000m^3
Smaller tanks for storing treated HFO.

The diesel tank is complete but the two HFO tanks are under construction. Treated HFO tanks are also under construction.

Fuel metering has been installed at each engine on the HFO system but it was not intended to be installed on the diesel system as this fuel would have only been used for short periods of time.

Photo 2, tanker unloading bay, 19 Feb 2010

Photo 3, diesel oil storage tank

Photo 4, HFO tank

5.4.2 Re-configuring Fuel Storage

6000m^3 of diesel fuel will be sufficient to run the complete 100MW plant at full load for approximately 10 days. (We note however that the load connected to the local grid is presently insufficient to demand full load from the plant.)

If 10 days' storage is considered adequate, there is no need to complete the construction of the HFO tanks. However, it would seem sensible to complete the construction of the tank shells in any case, rather than abandon part-constructed tanks to deteriorate. If the HFO system is not to be used the tanks and pipes would be better left un-insulated. It is likely that rain water will seep into the insulation and without heat to dry it out, the water is likely to corrode the underlying steelwork and damage the insulation.

If fuel storage of 20 or 30 days is preferred, the HFO tanks can be completed and used for diesel storage, though thermal insulation can be ignored. A close examination of the existing piping should quickly determine how best to connect the HFO tanks into the existing diesel fuel system.

The smaller HFO tanks, designated for the short-term storage and buffering of fuel after heating and centrifuging, may be mothballed with desiccant and sealed.

If it is required that the consumption of diesel oil be metered, the meters installed on the HFO pipework to each engine may be removed and installed in the diesel fuel pipework instead.

6. Staffing Requirements for the Use of HFO

The plant is currently in the installation and commissioning phases hence under the supervision of LBG staff. LBG have engaged local Afghan staff and other ex-pats who are expected to leave the employment of LBG and join the power plant operations organization when LBG hand over the station. These staff include some experienced people from outside Afghanistan.

LBG is just beginning their operator training program and estimate that untrained staff could be fully trained to operate the plant in 3 to 5 years. LBG are currently preparing training materials and starting to process the first group of trainees.

As previously discussed, running on HFO has a higher operation and maintenance burden than running on diesel oil because plant overhauls are more frequent and more plant is in use. Engines that have run to date have only run on diesel oil.

Operating the plant on diesel oil only will certainly make staff training easier and fewer competent staff will be required to keep the mechanical aspects of the plant in working order. From the staff training point of view, there are clear benefits to operating the plant on diesel oil and perhaps moving on to operating on HFO in future years.

We do not know how many staff LBG envisage using to run the station. Typically in the USA, a plant of this nature would have a total staff contingent of perhaps 20. In under-developed countries, a similar plant might employ three times as many, though at a much lower cost. Compared with fuel costs, it is unlikely that staffing costs in Afghanistan will have a significant impact on the economics of the plant, but staff can probably be cut by 20% if HFO is not used.

7. Availability and Cost of Fuel

The United States Geological Survey reports that though Afghanistan has not been thoroughly explored for oil and gas potential using the latest techniques, more than 150 million barrels of oil reserves have been identified using Soviet methods and technologies in 29 fields in the Afghan portion of the Amu Darya and Afghan-Tajik basins.

Only a very small portion of this reported resource base has been exploited, and there do not seem to be supplies of indigenous heavy fuel oil available at this time. As there are no other substantial HFO installations near Kabul, there is no established supply of HFO to the region.

The Amu Darya basin extends into Turkmenistan, Uzbekistan, and Iran, and has been exploited in these regions. It was once, but is no longer, part of the same geological feature as the Afghan-Tajik basin, and though both basins are gas dominated, small but significant reserves of liquids are also present.

HFO and diesel oil are both available in Turkmenistan, Uzbekistan, Kazakhstan and Iran, though the over-land access to Kabul is difficult, especially in winter. A better, more established source of fuel is Pakistan. Fuel oils are currently exported from Pakistan to Afghanistan by NAPCO, an Afghan company, though we understand that this is mainly diesel or furnace oils which do not need heated tankers.

Preliminary enquiries with the COO of DABS (Afghanistan's national energy utility) indicate a reasonable level of confidence that obtaining a fuel supply in the quantities required can be achieved. However Tryco International, who supply aviation fuel to Kabul, advise that a sufficient number of heated tankers to transport the required quantities of heavy fuel oil from outside Afghanistan are not available and such tankers would have to be provided by the power station or their procurement negotiated with fuel suppliers.

8. Conclusions and Recommendations

8.1 Conclusions

a) The plant as designed is perfectly capable of operating on either diesel oil or HFO, and is typical of HFO power plant operating successfully worldwide.

b) Operating on HFO at close to full load will provide fuel savings in the region of $27 million per annum, at current marine bunker prices, when compared to operating on diesel oil. We understand however that the plant is unlikely to be able to operate at full load in the near-term and perhaps 20% load would be more realistic at this time.

c) LBG have advised that staff training is likely to take 3 to 5 years before fully competent indigenous operation and maintenance staff are available. Operating on diesel oil rather than HFO will make staff training simpler and could be an effective way of introducing the power plant to the local workforce, with a view to moving to HFO operation at a later date.

d) The HFO systems are not ready for commissioning yet. Preparing HFO plant for long term storage and preservation does not present difficult challenges.

e) Indications are that adequate supplies of diesel oil or HFO can be secured.

8.2 Recommendations

We appreciate that there are significant ramifications beyond the engineering aspects to the final decisions made with regard to the completion and future support of this power plant, and consideration of these issues lies outside both the scope of this study and our area of expertise. The following are therefore based only on technical and commercial considerations, combined with experience of commissioning and operating this sort of plant in under-developed countries.

a) We recommend that the plant is run on HFO in the medium to long term. This will take advantage of the considerable fuel cost savings available to a plant that has been designed for this fuel.

b) We recommend that in the short term, the plant should be commissioned and operated on diesel fuel. This will have operational and practical benefits, including making it easier to deal with the relatively low loads available; and simplifying the training of operations and maintenance staff when starting from a very low base of skills and understanding.

c) In order to facilitate the above two recommendations, we further recommend that the completion and commissioning of the power plant is split into two parts.

   Firstly the plant should be completed and commissioned on diesel fuel only. Equipment not required for diesel fuel operation, including the fuel treatment plant and the thermal oil system, should be preserved in its present state with no further installation work done.

   We recommend that the construction of HFO storage tank shells is completed but stopped before the insulation is installed, and the tanks sealed and preserved.

   The second phase of commissioning is covered in below.

d) If the recommendations above are enacted, staff training should be focused on diesel only operation at this time, with further training on the HFO aspects of the plant in future.

e) When staff have become competent to operate the plant on diesel fuel, and when significant load growth is achieved, the second phase of commissioning should be carried out in tandem with further staff training. In this phase, the installation of the HFO equipment would be completed and the HFO systems commissioned, followed by gradually phasing in the use of HFO, engine by engine.

9. References

Report: Contract Delays Led to Cost Overruns for the Kabul Power Plant and Sustainability Remains a Key Challenge, by the Office of the Special Inspector General for Afghanistan Reconstruction, January 20, 2010.

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APPENDIX B
PHOENIX HFO EVALUATION

Tarakhil Power Plant (18x6.2 MW)

Generation Cost Comparison Diesel vs. HFO - Base Load Operations (24 Hrs.)

Fuel	Capacity (MW)	Units Generated per Day (KWH)	Fuel Consumed per Day (Litres)	Total Cost of Fuel (Af.)	Sp. Fuel Consumption (ml./KWH)	Fuel Cost of Generation/KWH	
						Af/KWH	US ₵/KWH
Diesel	6.2	148800	35712	2142720	240	14.40	25.44
HFO	6.2	148800	32605	1701984	219	11.44	20.21
Difference in Fuel Cost of Generation						2.96	5.23
% Difference						21%	21%

Assumptions:

1. Cost of Diesel/Ltr.: Af 60/Ltr.
2. Cost of HFO/Ltr.: Af 47.2/Ltr. (based on the current Indian rate of INR 52.2/Ltr.).
3. The HFO rate for above calculation of cost of generation at Tarakhil is assumed to be higher by 10% than the Indian rate. HFO rate for Afghanistan not available.

Additional Cost of Generation for 6 Hrs. Per Day HFO Operations

Fuel	Cost of running 2 Aux. Boilers for 18 Hrs. on Diesel (Af)	Cost of running Thermal Cycle Pumps for 18 Hrs. on electric power (Af)	Cost of flushing Engines with Diesel (Af)	Total Additional Cost (Af)	Total Additional Cost of Generation/KWH		Total Fuel Cost of Generation/KWH	
					Af/KWH	US ₵/KWH	Af./KWH	US ₵/KWH
Diesel	-	-	-	-	-	-	14.40	25.44
HFO	388800	7272	30000	426072	1.42	2.51	12.86	22.72
Difference in Fuel Cost of Generation							1.54	2.72
% Difference							11%	11%

Assumptions:

Additional costs will be incurred for peak load operations of 6 hours per day, details of which are as follows:

1. Heating of HFO by running 2 Auxiliary Boilers for balance 18 hours. Diesel conumption for each boiler = 180 Litres/hour.
2. Cost of running 6 Thermal Cycle Pumps of total capacity of 50.5 KW (11 KW+0.25 KW+2x15 KW+5.5 KW+3.75 KW) for 18 hours. Cost of power assumed = 8 Af/KWH.
3. Engines will need to be flushed every day with Diesel. Diesel required = 500 Litres/Day.

Fuel	Total Capacity (MW)	Capacity Operated (MW)	Units Generated for 6 Hrs Operation per Day (KWH)	Units Generated for 12 Hrs Operation per Day	Fuel Consumption per Day for 6 Hrs of Operations (Litres)	Fuel Consumption per Day for 12 Hrs of Operations (Litres)	Fuel Consumption per Month for 6 Hrs of Operations (Litres)	Fuel Consumption per Month for 12 Hrs of Operations (Litres)	Fuel required for Winter Operations (Nov 2014 - Mar 2015) for 6 Hrs. of Operations (Litres)	Fuel required for Winter Operations (Nov 2014 - Mar 2015) for 12 Hrs. of Operations (Litres)
Diesel	111.6	50	300000	600000	72000	144000	2160000	4320000	10800000	21600000
HFO	111.6	50	300000	600000	65736	131472	1972080	3944160	9860400	19720800

Fuel	Fuel Consumption per Month for 50 MW of Operations for 6 Hrs per day (Litres)	Fuel Consumption per Month for 50 MW of Operations for 12 Hrs per Day (Litres)	Fuel required for 50 MW Winter Operations (Nov 2014 - Mar 2015) for 6 Hrs. of Operations (million Litres)	Fuel required for 50 MW Winter Operations (Nov 2014 - Mar 2015) for 12 Hrs. of Operations (million Litres)
Diesel	2160000	4320000	10.8	21.6
HFO	1972080	3944160	9.86	19.72

APPENDIX C
COMPRESSED NATURAL GAS PIPING CALCULATIONS

Pipeline Sizing Summary

TPP Fuel Flowrate	1.16E+07	L/hr	(0°C, 1 Bar)	
Pipeline Capacity Factor	5			
Design Flowrate	5.80E+07	L/hr	(0°C, 1 Bar)	
Design Pressure	68	Bar		
Design Temp	25	°C		
Design Flowrate	9.31E+05	L/hr	(Design Temp, Design Pressure)	
Design Gas Velocity	10	m/s		
Min Flow Area	0.025859671	m2		
Minimum Diameter	0.181454004	m		
Minimum Diameter	0.580652812	ft	6.967834	in

**Assume single 203.2mm (8") ID pipe to be used

Pipeline Parametric Estimating

TAPI			
Diameter	1420	mm	
Pressure	101.325	bar	
Length	1735	km	
Capacity	3.30E+10	m3/yr	(STP)
	3.56E+08	m3/yr	(Design Pressure / 25°C)
Compressor Spacing	289	km/segment	
Cost	7.60E+09	USD	
Gas Velocity	7.118324259	m/s	
	23.35408222	ft/s	
Parametric Pricing	3084.791168	$/(mm*km)	
	126071.0963	$/(inch*mile)	
Total Pipeline CAPEX	$ 319,056,248.73		

APPENDIX D
PRO FORMA FINANCIAL ANALYSIS WORKSHEET

<u>Base Case</u>: DIESEL POWER GENERATION (Base Load, Normal Operation)

Design Input	Parameters	Unit
Electricity Tariffs (ET)	0.18	$/kWh
Base Load (BL)	100	MW
Days Run /Year (D)	330	Days
Daily Capacity Factor at BL (CF)	80%	24-Hr Duty Cycle
Annual plant degradation (AD)	0%	
Foreign/Gov. Subsidy (SDY)		$/kWh
Diesel Fuel Cost (FC)	1.10	$/Litre
Diesel Fuel Consumption (L)	250.00	L/MWh
Fuel Transportation Cost (FT)	0.00	$/MWh
Other Direct Costs (OC)	5.1	$/MWh
Fixed O&M Cost (OM)	500,000	$/Year
Other Indirect Cost (IC)	0	$/MWh
Existing Loan Interest Rate (IR)	4.50%	
Existing Loan Amount (LA)	-	$
Existing Terms of Loan (TL)	10	Year
Total Power Plant Assets (TA)	$ 100,000,000	$ at Year 0
Salvage Value of Power Plant (SV)	$ 10,000,000	$ at Year 20
Power Plant Design Life (DL)	$ 20	Year
New Investment Loan Amount (NI)		$ at Year 0
New Investment Interest Rate (NIR)	4.50%	
New Investment Loan Terms (NIT)	20	Year
DABS Tax Liability (TAX)	0%	
Discount Rate	9.50%	

<u>Assumptions</u>
1. TPP runs at 80% capacity on base-load (24/7)
2. TPP operates on diesel fuel at current market price
3. No investments to upgrade or improve exsiting power plant systems
4. Per TPP, variable tariffs are 5-10 AFN/kWh. LFO costs 60 AFN/Litre. LFO consumption 250 L/MWh. Fixed O&M Cost = $500k/year. 1 USD = 55 AFN.

<u>Results of Pro-forma Financial Analysis</u>
1. With no aids and at highest current tariffs, operating loss is $75 millions annually
2. Total NPV of loss is $661 millions after 20 years

PRO-FORMA FINANCIAL ANALYSIS TABLE	Year	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
	No. of Year (n)	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Revenues	Formula																					
1. Electricity Tariffs																						
Generation (MWh)	BL*D*CF*(1-AD)	633,600	633,600	633,600	633,600	633,600	633,600	633,600	633,600	633,600	633,600	633,600	633,600	633,600	633,600	633,600	633,600	633,600	633,600	633,600	633,600	633,600
Sales of Electricity (x$1000)	MWh*ET	$ 114,048	$ 114,048	$ 114,048	$ 114,048	$ 114,048	$ 114,048	$ 114,048	$ 114,048	$ 114,048	$ 114,048	$ 114,048	$ 114,048	$ 114,048	$ 114,048	$ 114,048	$ 114,048	$ 114,048	$ 114,048	$ 114,048	$ 114,048	$ 114,048
2. Foreign/Gov. Subsidy (x1000$)	MWhxSDY	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
3. Other Revenues (x1000$)																						
Total Revenues		$ 114,048	$ 114,048	$ 114,048	$ 114,048	$ 114,048	$ 114,048	$ 114,048	$ 114,048	$ 114,048	$ 114,048	$ 114,048	$ 114,048	$ 114,048	$ 114,048	$ 114,048	$ 114,048	$ 114,048	$ 114,048	$ 114,048	$ 114,048	$ 114,048
Expenses																						
1. Direct Costs																						
Fuel Consumption (L)	MWh*L	158,400,000	158,400,000	158,400,000	158,400,000	158,400,000	158,400,000	158,400,000	158,400,000	158,400,000	158,400,000	158,400,000	158,400,000	158,400,000	158,400,000	158,400,000	158,400,000	158,400,000	158,400,000	158,400,000	158,400,000	158,400,000
Fuel Costs (x$1000)	L*FC	$ 174,240	$ 174,240	$ 174,240	$ 174,240	$ 174,240	$ 174,240	$ 174,240	$ 174,240	$ 174,240	$ 174,240	$ 174,240	$ 174,240	$ 174,240	$ 174,240	$ 174,240	$ 174,240	$ 174,240	$ 174,240	$ 174,240	$ 174,240	$ 174,240
Fuel transportation Cost (x$1000)	MWh*FT	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Other Direct Costs (x$1000)	MWh*OC	$ 3,231	$ 3,231	$ 3,231	$ 3,231	$ 3,231	$ 3,231	$ 3,231	$ 3,231	$ 3,231	$ 3,231	$ 3,231	$ 3,231	$ 3,231	$ 3,231	$ 3,231	$ 3,231	$ 3,231	$ 3,231	$ 3,231	$ 3,231	$ 3,231
Sub-Total Direct Costs		**$ 177,471**	**$ 177,471**	**$ 177,471**	**$ 177,471**	**$ 177,471**	**$ 177,471**	**$ 177,471**	**$ 177,471**	**$ 177,471**	**$ 177,471**	**$ 177,471**	**$ 177,471**	**$ 177,471**	**$ 177,471**	**$ 177,471**	**$ 177,471**	**$ 177,471**	**$ 177,471**	**$ 177,471**	**$ 177,471**	**$ 177,471**
2. Indirect Costs																						
Fixed O&M (x$1000)	OM	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500
Other Indirect Costs (x$1000)		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sub-Total InDirect Costs		**$ 500**	**$ 500**	**$ 500**	**$ 500**	**$ 500**	**$ 500**	**$ 500**	**$ 500**	**$ 500**	**$ 500**	**$ 500**	**$ 500**	**$ 500**	**$ 500**	**$ 500**	**$ 500**	**$ 500**	**$ 500**	**$ 500**	**$ 500**	**$ 500**
3. Finance Costs																						
Loan & Mortgage payment (x$1000)	Fx: PMT	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Other Finance Costs		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Sub-Total Finance Costs		**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**
4. Depreciation Costs	Fx:DB	$ -	$ 10,900	$ 10,900	$ 10,900	$ 10,900	$ 10,900	$ 10,900	$ 10,900	$ 10,900	$ 10,900	$ 10,900	$ 10,900	$ 10,900	$ 10,900	$ 10,900	$ 10,900	$ 10,900	$ 10,900	$ 10,900	$ 10,900	$ 10,900
5. Other Expenses		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total Expenses		177,971	188,871	188,871	188,871	188,871	188,871	188,871	188,871	188,871	188,871	188,871	188,871	188,871	188,871	188,871	188,871	188,871	188,871	188,871	188,871	188,871
Alternative Fuel Investment																						
Base Case: No Investment																						
1. Tarakhil Plant Modification Cost																						
Updrade existing diesel fuel system	($x1000)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Convert systems to accept dual fuels	($x1000)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
New fuel unloading plant & fuel storage	($x1000)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Integration Cost	($x1000)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Sub-Total Modification Costs		**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**
2. Alternative Fuel Cost																						
CAPEX to explore new fuel source																						
Study and Exploration	($x1000)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Design-Build new pipelines	($x1000)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Upgrade infrastructures	($x1000)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Upgrade processing plant & facilities	($x1000)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Other Fees and Royalities	($x1000)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Finance Cost																						
Loan & Interests	FX:PMT	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
3. Other Investment Costs	($x1000)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Sub-Total Modification Costs		**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**
Total Investment		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
FINANCIAL FEASIBILITY ANALYSIS																						
1. Net Income Before Tax (NET)	(Rev-Exp) ($x1000)	($63,923)	($74,823)	($74,823)	($74,823)	($74,823)	($74,823)	($74,823)	($74,823)	($74,823)	($74,823)	($74,823)	($74,823)	($74,823)	($74,823)	($74,823)	($74,823)	($74,823)	($74,823)	($74,823)	($74,823)	($74,823)
2. Tax (TX)	Tax*NET ($x1000)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
3. Earning After Tax (EA)	NET-TX ($x1000)	($63,923)	($74,823)	($74,823)	($74,823)	($74,823)	($74,823)	($74,823)	($74,823)	($74,823)	($74,823)	($74,823)	($74,823)	($74,823)	($74,823)	($74,823)	($74,823)	($74,823)	($74,823)	($74,823)	($74,823)	($74,823)
4. Net Present Value (NPV, x$1000)	NPV Year 0	**(660,544)**																				
5. Benefit-Cost Ratio (BCR)	(Rev/Exp)	0.64	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
6. Pay-Back on Investment (Year)		N/A																				
7. Internal Rate of Return (IRR)	FX:IRR	N/A																				

Case 1 : DIESEL POWER GENERATION (Base Load with Foreign Aids/Government Subsidy)

Design Input	Parameters	Unit
Electricity Tariffs (ET)	0.276	$/kWh
Base Load (BL)	100	MW
Days Run /Year (D)	330	Days
Daily Capacity Factor at BL (CF)	80%	24-Hr Duty Cycle
Annual plant degradation (AD)	0%	
Foreign/Gov. Subsidy (SDY)	$0.000	$/kWh
Diesel Fuel Cost (FC)	1.06	$/Litre
Diesel Fuel Consumption (L)	240.00	L/MWh
Fuel Transportation Cost (FT)	0.00	$/MWh
Other Direct Costs (OC)	5.10	$/MWh
Fixed O&M Cost (OM)	500,000	$/Year
Other Indirect Cost (IC)	0.00	$/MWh
Inflation Rate (IFR)	6.00%	
Existing Loan Interest Rate (IR)	4.50%	
Existing Loan Amount (LA)	-	$
Existing Terms of Loan (TL)	10	Year
Total Power Plant Assets (TA)	$ 100,000,000	$ at Year 0
Salvage Value of Power Plant (SV)	$ 10,000,000	$ at Year 20
Power Plant Design Life (DL)	$ 20	Year
New Investment Loan Amount (NI)		$ at Year 0
New Investment Interest Rate (NIR)	4.50%	
New Investment Loan Terms (NIT)	20	Year
DABS Tax Liability (TAX)	0%	
Discount Rate	9.50%	

INSTRUCTION: Manipulate $/kWh to obtain minimum aid/subsidy that yields positive Net Income

Assumptions
1. TPP runs at 80% capacity on base-load (24/7)
2. TPP operates on diesel fuel at current market price
3. No investments to upgrade or improve exsiting power plant systems
4. Per TPP, variable tariffs are 5-10 AFN/kWh. LFO costs 60 AFN/Litre. Diesel fuel consumption 240 L/MWh. Fixed O&M Cost = $500k/year. 1 USD = 56.6 AFN.

Results of Pro-forma Financial Analysis

1. Min. government subsidy to NPV>0 , at current tariff	**0 $/kWh**
2. Total Aid/Subsidy required at current tariff @base load	**$0million/year**
3. Without Aid/Subsidy, electricity tariff shall be raised to	**$0.276/kWh**
4. NPV	**$0 millions**
5. BCR	**0.997**

PRO-FORMA FINANCIAL ANALYSIS TABLE	Year	2015	2016	2017	2018	2019	2020	2021	2022	2023
	No. of Year (n)	0	1	2	3	4	5	6	7	8
Revenues	Formula									
1. Electricity Tariffs										
Generation (MWh)	BL*D*CF*(1-AD)	633,600	633,600	633,600	633,600	633,600	633,600	633,600	633,600	633,600
Sales of Electricity (x$1000)	MWh*ET	$ 174,708	$ 174,708	$ 174,708	$ 174,708	$ 174,708	$ 174,708	$ 174,708	$ 174,708	$ 174,708
2. Foreign/Gov. Subsidy (x1000$)	MWhxSDY	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
3. Other Revenues (x1000$)		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total Revenues		$ 174,708	$ 174,708	$ 174,708	$ 174,708	$ 174,708	$ 174,708	$ 174,708	$ 174,708	$ 174,708
Expenses										
1. Direct Costs										
Fuel Consumption (L)	MWh*L	152,064,000	152,064,000	152,064,000	152,064,000	152,064,000	152,064,000	152,064,000	152,064,000	152,064,000
Fuel Costs (x$1000)	L*FC	$ 161,188	$ 161,188	$ 161,188	$ 161,188	$ 161,188	$ 161,188	$ 161,188	$ 161,188	$ 161,188
Fuel transportation Cost (x$1000)	MWh*FT	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Other Direct Costs (x$1000)	MWh*OC	$ 3,231	$ 3,231	$ 3,231	$ 3,231	$ 3,231	$ 3,231	$ 3,231	$ 3,231	$ 3,231
Sub-Total Direct Costs		**$ 164,419**	**$ 164,419**	**$ 164,419**	**$ 164,419**	**$ 164,419**	**$ 164,419**	**$ 164,419**	**$ 164,419**	**$ 164,419**
2. Indirect Costs										
Fixed O&M (x$1000)	MWh*OM	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500
Other Indirect Costs (x$1000)		-	-	-	-	-	-	-	-	-
Sub-Total InDirect Costs		**$ 500**	**$ 500**	**$ 500**	**$ 500**	**$ 500**	**$ 500**	**$ 500**	**$ 500**	**$ 500**
3. Finance Costs										
Loan & Mortgage payment (x$1000)	Fx: PMT	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Other Finance Costs		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Sub-Total Finance Costs		**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**
4. Depreciation Costs	Fx:DB	$ -	$ 10,900	$ 10,900	$ 10,900	$ 10,900	$ 10,900	$ 10,900	$ 10,900	$ 10,900
5. Other Expenses		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total Expenses		164,919	175,819	175,819	175,819	175,819	175,819	175,819	175,819	175,819
Alternative Fuel Investment										
Case 1: No Investment										
1. Tarakhil Plant Modification Cost										
Updrade existing diesel fuel system	($x1000)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Convert systems to accept dual fuels	($x1000)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
New fuel unloading plant & fuel storage	($x1000)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Integration Cost	($x1000)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Sub-Total Modification Costs		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
2. Alternative Fuel Cost										
CAPEX to explore new fuel source										
Study and Exploration	($x1000)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Design-Build new pipelines	($x1000)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Upgrade infrastructures	($x1000)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Upgrade processing plant & facilities	($x1000)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Other Fees and Royalities	($x1000)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Finance Cost										
Loan & Interests	FX:PMT	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
3. Other Investment Costs	($x1000)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Sub-Total Modification Costs		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total Investment		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
FINANCIAL FEASIBILITY ANALYSIS										
1. Net Income Before Tax (NET)	(Rev-Exp) ($x1000)	$9,789	($1,111)	($1,111)	($1,111)	($1,111)	($1,111)	($1,111)	($1,111)	($1,111)
2. Tax (TX)	Tax*NET ($x1000)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
3. Earning After Tax (EA)	NET-TX ($x1000)	$9,789	($1,111)	($1,111)	($1,111)	($1,111)	($1,111)	($1,111)	($1,111)	($1,111)
4. Net Present Value (NPV, x$1000)	NPV of Cash Flow	**(0)**								
5. Benefit-Cost Ratio (BCR)	(Rev/Exp)	1.06	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
6. Pay-Back on Investment (Year)		N/A								
7. Internal Rate of Return (IRR)	FX:IRR	N/A								

Case 1 : DIESEL POWER GENERATION (Base Load with Foreign Aids/Government Subsidy) Continued

2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
9	10	11	12	13	14	15	16	17	18	19	20
633,600	633,600	633,600	633,600	633,600	633,600	633,600	633,600	633,600	633,600	633,600	633,600
$ 174,708	$ 174,708	$ 174,708	$ 174,708	$ 174,708	$ 174,708	$ 174,708	$ 174,708	$ 174,708	$ 174,708	$ 174,708	$ 174,708
$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
$ 174,708	$ 174,708	$ 174,708	$ 174,708	$ 174,708	$ 174,708	$ 174,708	$ 174,708	$ 174,708	$ 174,708	$ 174,708	$ 174,708
152,064,000	152,064,000	152,064,000	152,064,000	152,064,000	152,064,000	152,064,000	152,064,000	152,064,000	152,064,000	152,064,000	152,064,000
$ 161,188	$ 161,188	$ 161,188	$ 161,188	$ 161,188	$ 161,188	$ 161,188	$ 161,188	$ 161,188	$ 161,188	$ 161,188	$ 161,188
$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
$ 3,231	$ 3,231	$ 3,231	$ 3,231	$ 3,231	$ 3,231	$ 3,231	$ 3,231	$ 3,231	$ 3,231	$ 3,231	$ 3,231
$ 164,419	**$ 164,419**	**$ 164,419**	**$ 164,419**	**$ 164,419**	**$ 164,419**	**$ 164,419**	**$ 164,419**	**$ 164,419**	**$ 164,419**	**$ 164,419**	**$ 164,419**
$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500
-	-	-	-	-	-	-	-	-	-	-	-
$ 500	**$ 500**	**$ 500**	**$ 500**	**$ 500**	**$ 500**	**$ 500**	**$ 500**	**$ 500**	**$ 500**	**$ 500**	**$ 500**
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$ 10,900	$ 10,900	$ 10,900	$ 10,900	$ 10,900	$ 10,900	$ 10,900	$ 10,900	$ 10,900	$ 10,900	$ 10,900	$ 10,900
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175,819	175,819	175,819	175,819	175,819	175,819	175,819	175,819	175,819	175,819	175,819	175,819
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($1,111)	($1,111)	($1,111)	($1,111)	($1,111)	($1,111)	($1,111)	($1,111)	($1,111)	($1,111)	($1,111)	($1,111)
$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
($1,111)	($1,111)	($1,111)	($1,111)	($1,111)	($1,111)	($1,111)	($1,111)	($1,111)	($1,111)	($1,111)	($1,111)
0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99

Case 2 : POWER GENERATION WITH HEAVY FUEL OIL (Base Load)

Design Input	Parameters	Unit
Electricity Tariffs (ET)	0.276	$/kWh
Base Load (BL)	100	MW
Days Run /Year (D)	330	Days
Daily Capacity Factor at BL (CF)	80%	24-Hr Duty Cycle
Annual plant degradation (AD)	0%	
Foreign/Gov. Subsidy (SDY)	$0.000	$/kWh
HFO Fuel Cost (FC)	0.90	$/Litre
HFO Consumption (L)	219.00	L/MWh
Fuel Transportation Cost (FT)	0.00	$/MWh
Other Direct Costs (OC)	5.1	$/MWh
Fixed O&M Cost (OM)	500,000	$/Year
Other Indirect Cost (IC)	0	$/MWh
Existing Loan Interest Rate (IR)	4.50%	
Existing Loan Amount (LA)	-	$
Existing Terms of Loan (TL)	10	Year
Total Power Plant Assets (TA)	$ 100,000,000	$ at Year 0
Salvage Value of Power Plant (SV)	$ 10,000,000	$ at Year 20
Power Plant Design Life (DL)	$ 20	Year
New Investment Loan Amount (NI)		$ at Year 0
New Investment Interest Rate (NIR)	4.50%	
New Investment Loan Terms (NIT)	20	Year
DABS Tax Liability (TAX)	0%	
Discount Rate	9.50%	

INSTRUCTION: Manipulate $/kWh to obtain minimum electricity tariff that yields positive Net Income

Assumptions
1. TPP runs at 80% capacity on base-load (24/7)
2. TPP operates on HFO at current market price
3. AID invests $16.5 millionfor plant upgrades. Min. impact during upgrades
4. Per TPP, variable tariffs are 5-10 AFN/kWh. HFO costs 50 AFN/Litre transport incl. LFO consumption 250 L/MWh. Fixed O&M Cost = $500k/year. 1 USD = 55 AFN.

Results of Pro-forma Financial Analysis	
1. Min. electricity price to yield NPV>0 with no gov. subsidy	**0.276 $/kWh**
2. Payback of investment	**5 Years**
3. IRR	**#NUM!**
4. NPV	**$311747 millions**
5. BCR	**1.251**

PRO-FORMA FINANCIAL ANALYSIS TABLE	Year	2015	2016	2017	2018	2019	2020	2021	2022	2023
	No. of Year (n)	0	1	2	3	4	5	6	7	8
Revenues	Formula									
1. Electricity Tariffs										
Generation (MWh)	BL*D*CF*(1-AD)	633,600	633,600	633,600	633,600	633,600	633,600	633,600	633,600	633,600
Sales of Electricity (x$1000)	MWh*ET	$ 174,874	$ 174,874	$ 174,874	$ 174,874	$ 174,874	$ 174,874	$ 174,874	$ 174,874	$ 174,874
2. Foreign/Gov. Subsidy (x1000$)	MWhxSDY	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
3. Other Revenues (x1000$)		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total Revenues		$ 174,874	$ 174,874	$ 174,874	$ 174,874	$ 174,874	$ 174,874	$ 174,874	$ 174,874	$ 174,874
Expenses										
1. Direct Costs										
Fuel Consumption (L)	MWh*L	138,758,400	138,758,400	138,758,400	138,758,400	138,758,400	138,758,400	138,758,400	138,758,400	138,758,400
Fuel Costs (x$1000)	L*FC	$ 124,883	$ 124,883	$ 124,883	$ 124,883	$ 124,883	$ 124,883	$ 124,883	$ 124,883	$ 124,883
Fuel transportation Cost (x$1000)	MWh*FT	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Other Direct Costs (x$1000)	MWh*OC	$ 3,231	$ 3,231	$ 3,231	$ 3,231	$ 3,231	$ 3,231	$ 3,231	$ 3,231	$ 3,231
Sub-Total Direct Costs		**$ 128,114**	**$ 128,114**	**$ 128,114**	**$ 128,114**	**$ 128,114**	**$ 128,114**	**$ 128,114**	**$ 128,114**	**$ 128,114**
2. Indirect Costs										
Fixed O&M (x$1000)	MWh*OM	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500
Other Indirect Costs (x$1000)		-	-	-	-	-	-	-	-	-
Sub-Total InDirect Costs		**$ 500**	**$ 500**	**$ 500**	**$ 500**	**$ 500**	**$ 500**	**$ 500**	**$ 500**	**$ 500**
3. Finance Costs										
Loan & Mortgage payment (x$1000)	Fx: PMT	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Other Finance Costs		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Sub-Total Finance Costs		**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**
4. Depreciation Costs	Fx:DB	$ -	$ 10,900	$ 10,900	$ 10,900	$ 10,900	$ 10,900	$ 10,900	$ 10,900	$ 10,900
5. Other Expenses		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total Expenses		128,614	139,514	139,514	139,514	139,514	139,514	139,514	139,514	139,514
Alternative Fuel Investment										
Option 2: Operate with HFO										
1. Tarakhil Plant Modification Cost										
Upgrade HFO piping & heating system	($x1000)	$ 6,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Re-Commissioing plant w/ HFO	($x1000)	$ 2,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
HFO pumping station, unloading plant	($x1000)	$ 3,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Integration Cost	($x1000)	$ 500	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Sub-Total Modification Costs		**$ 11,500**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**
2. Alternative Fuel Cost										
CAPEX to explore new fuel source										
Study and Exploration	($x1000)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Design-Build new pipelines	($x1000)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Design-Build or upgrade infrastructures	($x1000)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Buy HFO transporting trucks with insulated tank, heating and pumping system	($x1000)	$ 5,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Other Fees and Royalities	($x1000)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Finance Cost										
Loan & Interests	FX:PMT	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
3. Other Investment Costs	($x1000)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Sub-Total Alternative Fuel Costs		**$ 5,000**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**
Total Investment		$ 16,500	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
FINANCIAL FEASIBILITY ANALYSIS										
1. Net Income Before Tax (NET)	(Rev-Exp) ($x1000)	$29,760	$35,360	$35,360	$35,360	$35,360	$35,360	$35,360	$35,360	$35,360
2. Tax (TX)	Tax*NET ($x1000)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
3. Earning After Tax (EA)	NET-TX ($x1000)	$29,760	$35,360	$35,360	$35,360	$35,360	$35,360	$35,360	$35,360	$35,360
4. Net Present Value (NPV, x$1000)	NPV Year 0	**311,747**								
5. Benefit-Cost Ratio (BCR)	(Rev/Exp)	1.21	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
6. Pay-Back on Investment (Year)		5 Years								
7. Internal Rate of Return (IRR)	FX: IRR	#NUM!								

<u>Case 2</u> : POWER GENERATION WITH HEAVY FUEL OIL (Base Load) Continued

2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	
9	10	11	12	13	14	15	16	17	18	19	20	
633,600	633,600	633,600	633,600	633,600	633,600	633,600	633,600	633,600	633,600	633,600	633,600	
$ 174,874	$ 174,874	$ 174,874	$ 174,874	$ 174,874	$ 174,874	$ 174,874	$ 174,874	$ 174,874	$ 174,874	$ 174,874	$ 174,874	
$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	
$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	
$ 174,874	$ 174,874	$ 174,874	$ 174,874	$ 174,874	$ 174,874	$ 174,874	$ 174,874	$ 174,874	$ 174,874	$ 174,874	$ 174,874	
138,758,400	138,758,400	138,758,400	138,758,400	138,758,400	138,758,400	138,758,400	138,758,400	138,758,400	138,758,400	138,758,400	138,758,400	
$ 124,883	$ 124,883	$ 124,883	$ 124,883	$ 124,883	$ 124,883	$ 124,883	$ 124,883	$ 124,883	$ 124,883	$ 124,883	$ 124,883	
$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	
$ 3,231	$ 3,231	$ 3,231	$ 3,231	$ 3,231	$ 3,231	$ 3,231	$ 3,231	$ 3,231	$ 3,231	$ 3,231	$ 3,231	
$ 128,114	**$ 128,114**	**$ 128,114**	**$ 128,114**	**$ 128,114**	**$ 128,114**	**$ 128,114**	**$ 128,114**	**$ 128,114**	**$ 128,114**	**$ 128,114**	**$ 128,114**	
$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	
-	-	-	-	-	-	-	-	-	-	-	-	
$ 500	**$ 500**	**$ 500**	**$ 500**	**$ 500**	**$ 500**	**$ 500**	**$ 500**	**$ 500**	**$ 500**	**$ 500**	**$ 500**	
$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	
$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	
$ -	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	
$ 10,900	$ 10,900	$ 10,900	$ 10,900	$ 10,900	$ 10,900	$ 10,900	$ 10,900	$ 10,900	$ 10,900	$ 10,900	$ 10,900	
$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	
$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	
139,514	139,514	139,514	139,514	139,514	139,514	139,514	139,514	139,514	139,514	139,514	139,514	
$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	
$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	
$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	
$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	
$ -	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	
$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	
$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	
$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	
$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	
$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	
$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	
$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	
$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	
$ -	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	
$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 16,500
$35,360	$35,360	$35,360	$35,360	$35,360	$35,360	$35,360	$35,360	$35,360	$35,360	$35,360	$35,360	$736,953
$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	
$35,360	$35,360	$35,360	$35,360	$35,360	$35,360	$35,360	$35,360	$35,360	$35,360	$35,360	$35,360	
1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	$ 44.66

<u>Case 3 :</u> POWER GENERATION WITH NATURAL GAS (Base Load)

Design Input	Parameters	Unit
NG Electricity Tariffs (ET)	0.276	$/kWh
Base Load (BL)	100	MW
Days Run /Year (D)	330	Days
Daily Capacity Factor at BL (CF)	80%	24-Hr Duty Cycle
Annual plant degradation (AD)	0%	
Foreign/Gov. Subsidy (SDY)	$0.000	$/kWh
NG Fuel Cost (FC)	8.26E-04	$/L
NG Consumption (L)	104003.00	L/MWH
Fuel Transportation Cost (FT)		$/MWh
Other Direct Costs (OC)	6.5	$/MWh
Fixed O&M Cost (OM)	500,000	$/Year
Other Indirect Cost (IC)	0	$/MWh
Existing Loan Interest Rate (IR)	4.50%	
Existing Loan Amount (LA)	-	$
Existing Terms of Loan (TL)	10	Year
Total Power Plant Assets (TA)	$ 100,000,000	$ at Year 0
Salvage Value of Power Plant (SV)	$ 10,000,000	$ at Year 20
Power Plant Design Life (DL)	$ 20	Year
New Investment Loan Amount (NI)		$ at Year 0
New Investment Interest Rate (NIR)	4.50%	
New Investment Loan Terms (NIT)	20	Year
DABS Tax Liability (TAX)	0%	
Discount Rate	9.50%	

<u>INSTRUCTION</u>: Manipulate $/kWh to obtain minimum electricity tariff that yields positive NPV

<u>Assumptions</u>	
1. AID invests $330 million for new NG pipelines installation and plant upgrades	
2. During upgrades, TPP supplies peak load only (to avoid $ loss from generation)	
3. TPP will operate on 70% CNG at Pakistan OGDC pricing of $2.79/MMBtu.	
4. 30% of thermal load is DO at Af 60/L.	
5. Design & construction period (plant shut-down) = 36 months (2015-2017)	
6. NG processing plant is being constructed by others	
<u>Results of Pro-forma Financial Analysis</u>	
1. Min. electricity price to yield NPV>0 with no gov. subsidy	**0.276 $/kWh**
2. Payback of investment	**20 Years**
3. IRR	**19.74%**
4. NPV	**$333039 millions**
5. BCR	**2.149**

PRO-FORMA FINANCIAL ANALYSIS TABLE	Year	2015	2016	2017	2018	2019	2020	2021	2022	2023
	No. of Year (n)	0	1	2	3	4	5	6	7	8
Revenues	Formula									
1. Electricity Tariffs										
Generation (MWh)	BL*D*CF*(1-AD)	21,600	21,600	21,600	633,600	633,600	633,600	633,600	633,600	633,600
Sales of Electricity (x$1000)	MWh*ET	$ 3,888	$ 3,888	$ 3,888	$ 174,874	$ 174,874	$ 174,874	$ 174,874	$ 174,874	$ 174,874
2. Foreign/Gov. Subsidy (x1000$)	MWhxSDY	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
3. Other Revenues (x1000$)		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total Revenues		$ 3,888	$ 3,888	$ 3,888	$ 174,874	$ 174,874	$ 174,874	$ 174,874	$ 174,874	$ 174,874
Expenses										
1. Direct Costs										
Fuel Consumption (MBtu)	MWh*L	5,400,000	5,400,000	5,400,000	65,896,300,800	65,896,300,800	65,896,300,800	65,896,300,800	65,896,300,800	65,896,300,800
Fuel Costs (x$1000)	L*FC	$ 5,940	$ 5,940	$ 5,940	$ 54,430	$ 54,430	$ 54,430	$ 54,430	$ 54,430	$ 54,430
Fuel transportation Cost (x$1000)	MWh*FT	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Other Direct Costs (x$1000)	MWh*OC	$ 110	$ 110	$ 110	$ 4,118	$ 4,118	$ 4,118	$ 4,118	$ 4,118	$ 4,118
Sub-Total Direct Costs		**$ 6,050**	**$ 6,050**	**$ 6,050**	**$ 58,549**	**$ 58,549**	**$ 58,549**	**$ 58,549**	**$ 58,549**	**$ 58,549**
2. Indirect Costs										
Fixed O&M (x$1000)	MWh*OM	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500
Other Indirect Costs (x$1000)		-	-	-	-	-	-	-	-	-
Sub-Total InDirect Costs		**$ 500**	**$ 500**	**$ 500**	**$ 500**	**$ 500**	**$ 500**	**$ 500**	**$ 500**	**$ 500**
3. Finance Costs										
Loan & Mortgage payment (x$1000)	Fx: PMT	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Other Finance Costs		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Sub-Total Finance Costs		**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**
4. Depreciation Costs	Fx:DB	$ -	$ 10,900	$ 10,900	$ 10,900	$ 10,900	$ 10,900	$ 10,900	$ 10,900	$ 10,900
5. Other Expenses		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total Expenses		6,550	17,450	17,450	69,949	69,949	69,949	69,949	69,949	69,949
Alternative Fuel Investment										
Option 3: Operate with NG										
1. Tarakhil Plant Modification Cost										
Engine Conversion & Miscelaneous	($x1000)	$ -	$ 5,000	$ 20,000	$ -	$ -	$ -	$ -	$ -	$ -
Re-Commissioing plant w/ NG	($x1000)	$ -	$ -	$ 5,000	$ -	$ -	$ -	$ -	$ -	$ -
NG unloading plant	($x1000)	$ -	$ 5,000	$ 2,000	$ -	$ -	$ -	$ -	$ -	$ -
Integration Cost	($x1000)	$ -	$ -	$ 3,000	$ -	$ -	$ -	$ -	$ -	$ -
Sub-Total Modification Costs		**$ -**	**$ 10,000**	**$ 30,000**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**
2. Alternative Fuel Cost										
CAPEX to explore new fuel source										
Study and Exploration	($x1000)	$ 10,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Design-Build new pipelines	($x1000)	$ 150,000	$ 150,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Design-Build or upgrade infrastructures	($x1000)	$ 10,000	$ 10,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Buy LNG transporting trucks	($x1000)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Other Fees and Royalities	($x1000)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Finance Cost										
Loan & Interests	FX:PMT	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
3. Other Investment Costs	($x1000)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Sub-Total Modification Costs		**$ 170,000**	**$ 160,000**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**
Total Investment		$ 170,000	$ 170,000	$ 30,000	$ -	$ -	$ -	$ -	$ -	$ -
FINANCIAL FEASIBILITY ANALYSIS										
1. Net Income Before Tax (NET)	(Rev-Exp) ($x1000)	($172,662)	($183,562)	($43,562)	$104,925	$104,925	$104,925	$104,925	$104,925	$104,925
2. Tax (TX)	Tax*NET ($x1000)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
3. Earning After Tax (EA)	NET-TX ($x1000)	($172,662)	($183,562)	($43,562)	$104,925	$104,925	$104,925	$104,925	$104,925	$104,925
4. Net Present Value (NPV, x$1000)	NPV Year 0	**333,039**								
5. Benefit-Cost Ratio (BCR)	(Rev/Exp)	0.02	0.02	0.08	2.50	2.50	2.50	2.50	2.50	2.50
6. Pay-Back on Investment (Year)		20 Years								
7. Internal Rate of Return (IRR)	FX:IRR	19.74%								

Case 3 : POWER GENERATION WITH NATURAL GAS (Base Load) Continued

2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
9	10	11	12	13	14	15	16	17	18	19	20
633,600	633,600	633,600	633,600	633,600	633,600	633,600	633,600	633,600	633,600	633,600	633,600
$ 174,874	$ 174,874	$ 174,874	$ 174,874	$ 174,874	$ 174,874	$ 174,874	$ 174,874	$ 174,874	$ 174,874	$ 174,874	$ 174,874
$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
$ 174,874	$ 174,874	$ 174,874	$ 174,874	$ 174,874	$ 174,874	$ 174,874	$ 174,874	$ 174,874	$ 174,874	$ 174,874	$ 174,874
65,896,300,800	65,896,300,800	65,896,300,800	65,896,300,800	65,896,300,800	65,896,300,800	65,896,300,800	65,896,300,800	65,896,300,800	65,896,300,800	65,896,300,800	65,896,300,800
$ 54,430	$ 54,430	$ 54,430	$ 54,430	$ 54,430	$ 54,430	$ 54,430	$ 54,430	$ 54,430	$ 54,430	$ 54,430	$ 54,430
$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
$ 4,118	$ 4,118	$ 4,118	$ 4,118	$ 4,118	$ 4,118	$ 4,118	$ 4,118	$ 4,118	$ 4,118	$ 4,118	$ 4,118
$ 58,549	**$ 58,549**	**$ 58,549**	**$ 58,549**	**$ 58,549**	**$ 58,549**	**$ 58,549**	**$ 58,549**	**$ 58,549**	**$ 58,549**	**$ 58,549**	**$ 58,549**
$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500
-	-	-	-	-	-	-	-	-	-	-	-
$ 500	**$ 500**	**$ 500**	**$ 500**	**$ 500**	**$ 500**	**$ 500**	**$ 500**	**$ 500**	**$ 500**	**$ 500**	**$ 500**
$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
$ -	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**
$ 10,900	$ 10,900	$ 10,900	$ 10,900	$ 10,900	$ 10,900	$ 10,900	$ 10,900	$ 10,900	$ 10,900	$ 10,900	$ 10,900
$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
69,949	69,949	69,949	69,949	69,949	69,949	69,949	69,949	69,949	69,949	69,949	69,949
$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
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$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
$ -	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**
$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
$104,925	$104,925	$104,925	$104,925	$104,925	$104,925	$104,925	$104,925	$104,925	$104,925	$104,925	$104,925
$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
$104,925	$104,925	$104,925	$104,925	$104,925	$104,925	$104,925	$104,925	$104,925	$104,925	$104,925	$104,925
2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50

Case 1A : DIESEL POWER GENERATION (Peak Load with Foreign Aids, Operate till 2021)

Design Input	Parameters	Unit
Electricity Tariffs (ET)	0.269	$/kWh
Base Load (BL)	100	MW
Days Run /Year (D)	330	Days
Daily Capacity Factor at BL (CF)	80%	24-Hr Duty Cycle
Annual plant degradation (AD)	0%	
Foreign/Gov. Subsidy (SDY)	$0.000	$/kWh
Diesel Fuel Cost (FC)	1.06	$/Litre
Diesel Fuel Consumption (L)	240.00	L/MWh
Fuel Transportation Cost (FT)	0.00	$/MWh
Other Direct Costs (OC)	5.10	$/MWh
Fixed O&M Cost (OM)	500,000	$/Year
Other Indirect Cost (IC)	0.00	$/MWh
Existing Loan Interest Rate (IR)	4.50%	
Existing Loan Amount (LA)	-	$
Existing Terms of Loan (TL)	10	Year
Total Power Plant Assets (TA)	$ 100,000,000	$ at Year 0
Salvage Value of Power Plant (SV)	$ 10,000,000	$ at Year 20
Power Plant Design Life (DL)	$ 20	Year
New Investment Loan Amount (NI)		$ at Year 0
New Investment Interest Rate (NIR)	4.50%	
New Investment Loan Terms (NIT)	20	Year
DABS Tax Liability (TAX)	0%	
Discount Rate	9.50%	

INSTRUCTION: Manipulate $/kWh to obtain minimum aid/subsidy that yields positive Net Income

Assumptions
1. TPP supplies peak load only (30 days/year, 30% capacity)
2. TPP operates on diesel fuel at current market price
3. No investments to upgrade or improve exisiting power plant systems
4. Per TPP, variable tariffs are 5-10 AFN/kWh. LFO costs 60 AFN/Litre. Diesel fuel consumption 250 L/MWh. Fixed O&M Cost = $500k/year. 1 USD = 55 AFN.

Results of Pro-forma Financial Analysis	
1. Min. government subsidy to NPV>0 , at current tariff	**0 $/kWh**
2. Total Aid/Subsidy required at current tariff @base load	**$0million/year**
3. Without Aid/Subsidy, electricity tariff shall be raised to	**$0.269/kWh**
4. NPV	**$0 millions**
5. BCR	**0.979**

PRO-FORMA FINANCIAL ANALYSIS TABLE	Year	2015	2016	2017	2018	2019	2020	2021	2022
	No. of Year (n)	0	1	2	3	4	5	6	7
Revenues	Formula								
1. Electricity Tariffs									
Generation (MWh)	BL*D*CF*(1-AD)	633,600	633,600	633,600	633,600	633,600	633,600	633,600	-
Sales of Electricity (x$1000)	MWh*ET	$ 170,475	$ 170,475	$ 170,475	$ 170,475	$ 170,475	$ 170,475	$ 170,475	$ -
2. Foreign/Gov. Subsidy (x1000$)	MWhxSDY	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
3. Salvage Values (x1000$)		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 34,600
Total Revenues		$ 170,475	$ 170,475	$ 170,475	$ 170,475	$ 170,475	$ 170,475	$ 170,475	$ 34,600
Expenses									
1. Direct Costs									
Fuel Consumption (L)	MWh*L	152,064,000	152,064,000	152,064,000	152,064,000	152,064,000	152,064,000	152,064,000	-
Fuel Costs (x$1000)	L*FC	$ 161,188	$ 161,188	$ 161,188	$ 161,188	$ 161,188	$ 161,188	$ 161,188	$ -
Fuel transportation Cost (x$1000)	MWh*FT	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Other Direct Costs (x$1000)	MWh*OC	$ 3,231	$ 3,231	$ 3,231	$ 3,231	$ 3,231	$ 3,231	$ 3,231	$ -
Sub-Total Direct Costs		**$ 164,419**	**$ 164,419**	**$ 164,419**	**$ 164,419**	**$ 164,419**	**$ 164,419**	**$ 164,419**	**$ -**
2. Indirect Costs									
Fixed O&M (x$1000)	MWh*OM	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500
Other Indirect Costs (x$1000)		-	-	-	-	-	-	-	-
Sub-Total InDirect Costs		**$ 500**	**$ 500**	**$ 500**	**$ 500**	**$ 500**	**$ 500**	**$ 500**	**$ 500**
3. Finance Costs									
Loan & Mortgage payment (x$1000)	Fx: PMT	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Other Finance Costs		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Sub-Total Finance Costs		**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**
4. Depreciation Costs	Fx:DB	$ -	$ 10,900	$ 10,900	$ 10,900	$ 10,900	$ 10,900	$ 10,900	$ -
5. Other Expenses		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total Expenses		164,919	175,819	175,819	175,819	175,819	175,819	175,819	500
Alternative Fuel Investment									
Case 1: No Investment									
1. Tarakhil Plant Modification Cost									
Updrade existing diesel fuel system	($x1000)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Convert systems to accept dual fuels	($x1000)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
New fuel unloading plant & fuel storage	($x1000)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Integration Cost	($x1000)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Sub-Total Modification Costs		**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**
2. Alternative Fuel Cost									
CAPEX to explore new fuel source									
Study and Exploration	($x1000)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Design-Build new pipelines	($x1000)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Upgrade infrastructures	($x1000)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Upgrade processing plant & facilities	($x1000)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Other Fees and Royalities	($x1000)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Finance Cost									
Loan & Interests	FX:PMT	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
3. Other Investment Costs	($x1000)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Sub-Total Modification Costs		**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**
Total Investment		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
FINANCIAL FEASIBILITY ANALYSIS									
1. Net Income Before Tax (NET)	(Rev-Exp) ($x1000)	$5,556	($5,344)	($5,344)	($5,344)	($5,344)	($5,344)	($5,344)	$34,100
2. Tax (TX)	Tax*NET ($x1000)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
3. Earning After Tax (EA)	NET-TX ($x1000)	$5,556	($5,344)	($5,344)	($5,344)	($5,344)	($5,344)	($5,344)	$34,100
4. Net Present Value (NPV, x$1000)	NPV Year 0	**0**							
5. Benefit-Cost Ratio (BCR)	(Rev/Exp)	1.03	0.97	0.97	0.97	0.97	0.97	0.97	
6. Pay-Back on Investment (Year)		N/A							
7. Internal Rate of Return (IRR)	FX:IRR	N/A							

Case 2A : HFO POWER GENERATION (Base Load without without Aids, Operate till 2021)

INSTRUCTION: Manipulate $/kWh to obtain minimum aid/subsidy that yields positive Net Income

Design Input	Parameters	Unit
Electricity Tariffs (ET)	0.269	$/kWh
Base Load (BL)	100	MW
Days Run /Year (D)	365	Days
Daily Capacity Factor at BL (CF)	80%	24-Hr Duty Cycle
Annual plant degradation (AD)	0%	
Foreign/Gov. Subsidy (SDY)	$0.000	$/kWh
Diesel Fuel Cost (FC)	0.90	$/Litre
Diesel Fuel Consumption (L)	219.00	L/MWh
Fuel Transportation Cost (FT)	0.00	$/MWh
Other Direct Costs (OC)	5.10	$/MWh
Fixed O&M Cost (OM)	$ 500,000	$/Year
Other Indirect Cost (IC)	0.00	$/MWh
Existing Loan Interest Rate (IR)	4.50%	
Existing Loan Amount (LA)	-	$
Existing Terms of Loan (TL)	10	Year
Total Power Plant Assets (TA)	$ 100,000,000	$ at Year 0
Salvage Value of Power Plant (SV)	$ 10,000,000	$ at Year 20
Power Plant Design Life (DL)	$ 20	Year
New Investment Loan Amount (NI)		$ at Year 0
New Investment Interest Rate (NIR)	4.50%	
New Investment Loan Terms (NIT)	20	Year
DABS Tax Liability (TAX)	0%	
Discount Rate	9.50%	

Assumptions
1. TPP runs at 80% capacity on base-load (24/7)
2. TPP operates on HFO at current market price
3. AID invests $16.5 millionfor plant upgrades. Min. impact during upgrades
4. Per TPP, variable tariffs are 5-10 AFN/kWh. HFO costs 50 AFN/Litre transportation incl. Fuel consumption 250 L/MWh. Fixed O&M Cost = $500k/year. 1 USD = 55 AFN.

Results of Pro-forma Financial Analysis	
1. Min. electricity price to yield NPV>0 with no gov. subsidy	**0.269 $/kWh**
2. Payback of investment	**$0**
3. IRR	**#NUM!**
4. NPV	**$186.7 millions**
5. BCR	**1.225**

PRO-FORMA FINANCIAL ANALYSIS TABLE	Year	2015	2016	2017	2018	2019	2020	2021	2022	
	No. of Year (n)	0	1	2	3	4	5	6	7	
Revenues	Formula									
1. Electricity Tariffs										
Generation (MWh)	BL*D*CF*(1-AD)	700,800	700,800	700,800	700,800	700,800	700,800	700,800	-	
Sales of Electricity (x$1000)	MWh*ET	$ 188,515	$ 188,515	$ 188,515	$ 188,515	$ 188,515	$ 188,515	$ 188,515	$ -	
2. Foreign/Gov. Subsidy (x1000$)	MWhxSDY	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	
3. Salvage Values (x1000$)		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 34,600	
Total Revenues		$ 188,515	$ 188,515	$ 188,515	$ 188,515	$ 188,515	$ 188,515	$ 188,515	$ 34,600	
Expenses										
1. Direct Costs										
Fuel Consumption (L)	MWh*L	153,475,200	153,475,200	153,475,200	153,475,200	153,475,200	153,475,200	153,475,200	-	
Fuel Costs (x$1000)	L*FC	$ 138,128	$ 138,128	$ 138,128	$ 138,128	$ 138,128	$ 138,128	$ 138,128	$ -	
Fuel transportation Cost (x$1000)	MWh*FT	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	
Other Direct Costs (x$1000)	MWh*OC	$ 3,574	$ 3,574	$ 3,574	$ 3,574	$ 3,574	$ 3,574	$ 3,574	$ -	
Sub-Total Direct Costs		**$ 141,702**	**$ 141,702**	**$ 141,702**	**$ 141,702**	**$ 141,702**	**$ 141,702**	**$ 141,702**	**$ -**	
2. Indirect Costs										
Fixed O&M (x$1000)	MWh*OM	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	
Other Indirect Costs (x$1000)		-	-	-	-	-	-	-	-	
Sub-Total InDirect Costs		**$ 500**	**$ 500**	**$ 500**	**$ 500**	**$ 500**	**$ 500**	**$ 500**	**$ 500**	
3. Finance Costs										
Loan & Mortgage payment (x$1000)	Fx: PMT	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	
Other Finance Costs		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	
Sub-Total Finance Costs		**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	
4. Depreciation Costs	Fx:DB	$ -	$ 10,900	$ 10,900	$ 10,900	$ 10,900	$ 10,900	$ 10,900	$ -	
5. Other Expenses		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	
		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	
Total Expenses		142,202	153,102	153,102	153,102	153,102	153,102	153,102	500	
Alternative Fuel Investment										
Case 1: No Investment										
1. Tarakhil Plant Modification Cost										
Updrade existing diesel fuel system	($x1000)	$ 6,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	
Convert systems to accept dual fuels	($x1000)	$ 2,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	
New fuel unloading plant & fuel storage	($x1000)	$ 3,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	
Integration Cost	($x1000)	$ 500	$ -	$ -	$ -	$ -	$ -	$ -	$ -	
Sub-Total Modification Costs		**$ 11,500**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	
2. Alternative Fuel Cost										
CAPEX to explore new fuel source										
Study and Exploration	($x1000)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	
Design-Build new pipelines	($x1000)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	
Upgrade infrastructures	($x1000)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	
Buy HFO tracks	($x1000)	$ 5,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	
Other Fees and Royalities	($x1000)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	
Finance Cost										
Loan & Interests	FX:PMT	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	
3. Other Investment Costs	($x1000)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	
Sub-Total Modification Costs		**$ 5,000**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	
Total Investment		$ 16,500	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 16,500
FINANCIAL FEASIBILITY ANALYSIS										
1. Net Income Before Tax (NET)	(Rev-Exp) ($x1000)	$29,813	$35,413	$35,413	$35,413	$35,413	$35,413	$35,413	$34,100	
2. Tax (TX)	Tax*NET ($x1000)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	
3. Earning After Tax (EA)	NET-TX ($x1000)	$29,813	$35,413	$35,413	$35,413	$35,413	$35,413	$35,413	$34,100	$276,394
4. Net Present Value (NPV, x$1000)	NPV Year 0	**186,667**								
5. Benefit-Cost Ratio (BCR)	(Rev/Exp)	1.19	1.23	1.23	1.23	1.23	1.23	1.23		16.75
6. Pay-Back on Investment (Year)										
7. Internal Rate of Return (IRR)	FX:IRR	#NUM!								

Case 3A : NG POWER GENERATION (Base Load without Foreign Aids, Operate till 2021)

Design Input	Parameters	Unit
Electricity Tariffs (ET)	0.269	$/kWh
Base Load (BL)	100	MW
Days Run /Year (D)	330	Days
Daily Capacity Factor at BL (CF)	80%	24-Hr Duty Cycle
Annual plant degradation (AD)	0%	
Foreign/Gov. Subsidy (SDY)	$0.000	$/kWh
NG Fuel Cost (FC)	8.26E-04	$/L
NG Fuel Consumption (L)	104003.00	L/MWH
Fuel Transportation Cost (FT)		$/MWh
Other Direct Costs (OC)	6.5	$/MWh
Fixed O&M Cost (OM)	500,000	$/Year
Other Indirect Cost (IC)	0	$/MWh
Existing Loan Interest Rate (IR)	4.50%	
Existing Loan Amount (LA)	-	$
Existing Terms of Loan (TL)	10	Year
Total Power Plant Assets (TA)	$ 100,000,000	$ at Year 0
Salvage Value of Power Plant (SV)	$ 10,000,000	$ at Year 20
Power Plant Design Life (DL)	$ 20	Year
New Investment Loan Amount (NI)		$ at Year 0
New Investment Interest Rate (NIR)	4.50%	
New Investment Loan Terms (NIT)	20	Year
DABS Tax Liability (TAX)	0%	
Discount Rate	9.50%	

INSTRUCTION: Manipulate $/kWh to obtain minimum aid/subsidy that yields positive Net Income

Assumptions
1. AID invests $150 million for new NG pipelines installation and plant upgrades
2. During upgrades, TPP supplies peak load only (to avoid $ loss from generation)
3. TPP will operate on NG at AEIA's pricing of $3.06/MMBtu at base load
4. Design & construction period (plant shut-down) = 36 months (2015-2017)
5. NG processing plant is being constructed by others

Results of Pro-forma Financial Analysis

1. Min. electricity price to yield NPV>0 with no gov. subsidy	**0.269 $/kWh**
2. Payback of investment	**$0**
3. IRR	**2.19%**
4. NPV	**$-82190 millions**
5. BCR	**1.410**

PRO-FORMA FINANCIAL ANALYSIS TABLE	Year	2015	2016	2017	2018	2019	2020	2021	2022	
	No. of Year (n)	0	1	2	3	4	5	6	7	
Revenues	Formula									
1. Electricity Tariffs										
Generation (MWh)	BL*D*CF*(1-AD)	21,600	21,600	21,600	633,600	633,600	633,600	633,600	-	
Sales of Electricity (x$1000)	MWh*ET	$ 3,888	$ 3,888	$ 3,888	$ 170,438	$ 170,438	$ 170,438	$ 170,438	$ -	
2. Foreign/Gov. Subsidy (x1000$)	MWhxSDY	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	
3. Salvage Values (x1000$)		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 34,600	
Total Revenues		$ 3,888	$ 3,888	$ 3,888	$ 170,438	$ 170,438	$ 170,438	$ 170,438	$ 34,600	
Expenses										
1. Direct Costs										
Fuel Consumption (L)	MWh*L	5,400,000	5,400,000	5,400,000	65,896,300,800	65,896,300,800	65,896,300,800	65,896,300,800	-	
Fuel Costs (x$1000)	L*FC	$ 5,940	$ 5,940	$ 5,940	$ 54,430	$ 54,430	$ 54,430	$ 54,430	$ -	
Fuel transportation Cost (x$1000)	MWh*FT	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	
Other Direct Costs (x$1000)	MWh*OC	$ 110	$ 110	$ 110	$ 4,118	$ 4,118	$ 4,118	$ 4,118	$ -	
Sub-Total Direct Costs		**$ 6,050**	**$ 6,050**	**$ 6,050**	**$ 58,549**	**$ 58,549**	**$ 58,549**	**$ 58,549**	**$ -**	
2. Indirect Costs										
Fixed O&M (x$1000)	MWh*OM	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	
Other Indirect Costs (x$1000)		-	-	-	-	-	-	-	-	
Sub-Total InDirect Costs		**$ 500**	**$ 500**	**$ 500**	**$ 500**	**$ 500**	**$ 500**	**$ 500**	**$ 500**	
3. Finance Costs										
Loan & Mortgage payment (x$1000)	Fx: PMT	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	
Other Finance Costs		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	
Sub-Total Finance Costs		**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	
4. Depreciation Costs	Fx:DB	$ -	$ 10,900	$ 10,900	$ 10,900	$ 10,900	$ 10,900	$ 10,900	$ -	
5. Other Expenses		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	
		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	
Total Expenses		6,550	17,450	17,450	69,949	69,949	69,949	69,949	500	
Alternative Fuel Investment										
Case 1: No Investment										
1. Tarakhil Plant Modification Cost										
Updrade existing diesel fuel system	($x1000)	$ -	$ 5,000	$ 20,000	$ -	$ -	$ -	$ -	$ -	
Convert systems to accept dual fuels	($x1000)	$ -	$ -	$ 5,000	$ -	$ -	$ -	$ -	$ -	
New fuel unloading plant & fuel storage	($x1000)	$ -	$ 5,000	$ 2,000	$ -	$ -	$ -	$ -	$ -	
Integration Cost	($x1000)	$ -	$ -	$ 3,000	$ -	$ -	$ -	$ -	$ -	
Sub-Total Modification Costs		**$ -**	**$ 10,000**	**$ 30,000**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	
2. Alternative Fuel Cost										
CAPEX to explore new fuel source										
Study and Exploration	($x1000)	$ 10,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	
Design-Build new pipelines	($x1000)	$ 150,000	$ 150,000	$ -	$ -	$ -	$ -	$ -	$ -	
Upgrade infrastructures	($x1000)	$ 10,000	$ 10,000	$ -	$ -	$ -	$ -	$ -	$ -	
Buy HFO tracks	($x1000)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	
Other Fees and Royalities	($x1000)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	
Finance Cost										
Loan & Interests	FX:PMT	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	
3. Other Investment Costs	($x1000)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	
Sub-Total Modification Costs		$ 170,000	$ 160,000	$ -	$ -	$ -	$ -	$ -	$ -	
Total Investment		$ 170,000	$ 170,000	$ 30,000	$ -	$ -	$ -	$ -	$ -	$ 370,000
FINANCIAL FEASIBILITY ANALYSIS										
1. Net Income Before Tax (NET)	(Rev-Exp) ($x1000)	($172,662)	($183,562)	($43,562)	$100,490	$100,490	$100,490	$100,490	$34,100	
2. Tax (TX)	Tax*NET ($x1000)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	
3. Earning After Tax (EA)	NET-TX ($x1000)	($172,662)	($183,562)	($43,562)	$100,490	$100,490	$100,490	$100,490	$34,100	$36,272
4. Net Present Value (NPV, x$1000)	NPV Year 0	**(82,190)**								
5. Benefit-Cost Ratio (BCR)	(Rev/Exp)	0.02	0.02	0.08	2.44	2.44	2.44	2.44		0.10
6. Pay-Back on Investment (Year)										
7. Internal Rate of Return (IRR)	FX:IRR	2.19%								

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